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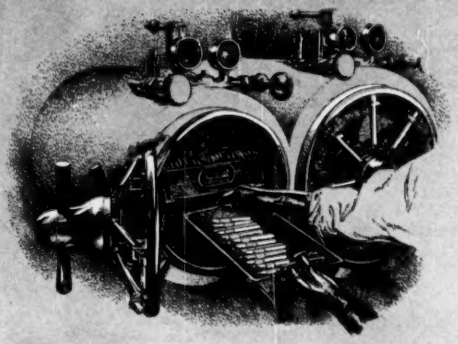

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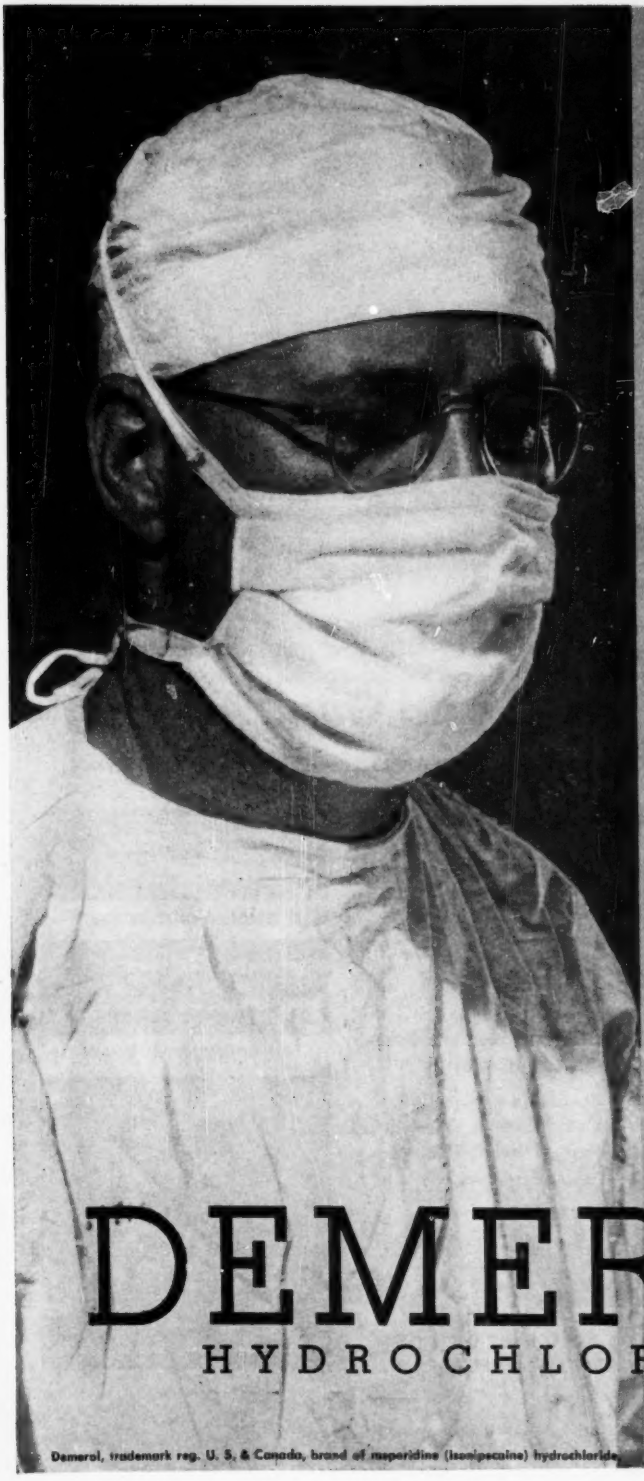

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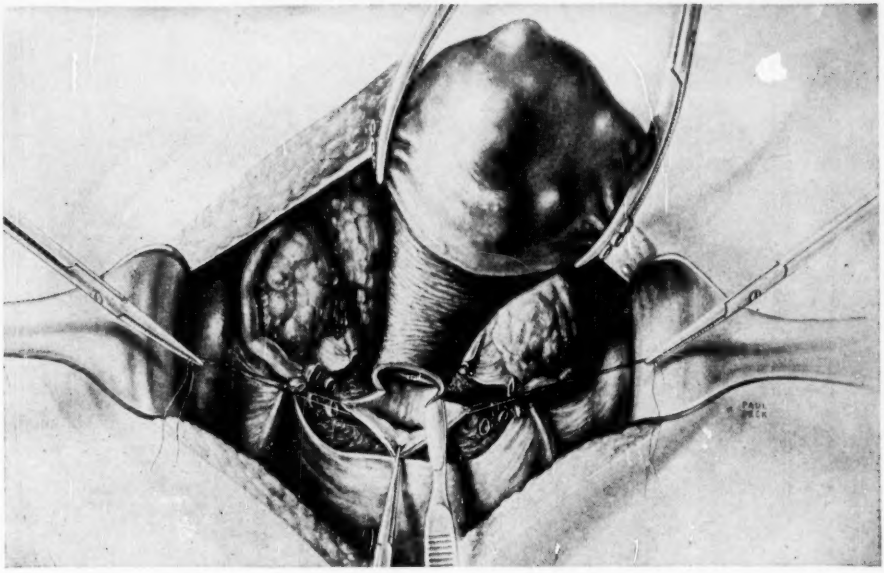

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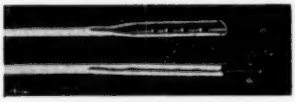

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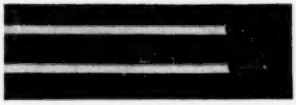

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SURGICAL APPROACH TO CANCER

JOHN J. MORTON, M.D.

ROCHESTER, N. Y.

UNTIL better methods of treatment become available surgical intervention has and will have a definite place in the therapy of cancer. The theory on which the surgical approach is based is that cancer is a lethal condition. When it once starts, the course is steadily progressive. Reversal of the growth and spontaneous cure is almost unknown, occurring in 1 of 100,000 cases according to Bashford, cited by Rae.[1] The rapidity of the process is conditioned by the age of the patient, the degree of differentiation of the cells, the hormone balance and other factors. In some instances the growth may be greatly retarded or even contained locally for considerable periods. But these instances are exceptional and not to be expected.

Surgical therapy should be based on accurate diagnosis because the surgical treatment of malignant growths is radical in type. Consequently few surgeons would feel on safe grounds if the complete radical resections were to be done on the basis of clinical symptoms and signs alone. For this reason some form of biopsy becomes essential, with expert interpretation of the type of tissue and its possibilities.

All the evidence that exists is that cancer in the early stages is a local disease and not the local manifestation of a generalized process. The leukemias may be considered an exception to this since the malignant cells arise in close contact with the blood stream and are generalized by the time they are recognized. In some cases of lymphosarcoma, plasma cell myeloma and Hodgkin's disease the condition seems to be widespread from the beginning. In others the condition appears locally at first and disseminates rather quickly at a later date.[2]

From the Department of Surgery, University of Rochester School of Medicine and Dentistry.

This address was presented at the Fourth International Cancer Research Congress, St. Louis, Sept. 3, 1947.

1. (*a*) Rae, M. V.: Spontaneous Regression of a Hypernephroma, Am. J. Cancer **24**:839-841, 1935. (*b*) Rohdenburg, G. L.: Fluctuations in the Growth Energy of Malignant Tumors in Man, with Especial Reference to Spontaneous Regression, J. Cancer Research **3**:193-225, 1918. (*c*) Shore, B. R.: Spontaneous Cure of a Congenital Recurring Connective Tissue Tumor, Am. J. Cancer **27**: 736-739, 1936.

2. (*a*) Craver, L. F.: Five Year Survivals in Hodgkin's Disease, Am. J. M. Sc. **188**:609-612, 1934. (*b*) Craver, L. F., in Pack, G. T., and Livingston,

(Footnote continued on next page)

The current theory is that most of these types arise in multiple centers. If all cancers could be recognized while still in the local phase, thorough removal would be curative. The surgeon in such happy circumstances would still face a dilemma because he could not be certain in any way at present whether the cancer had spread to the regional lymph nodes or through the blood stream. If he performed a local removal only, he would have to watch his patient carefully for several years to determine whether there had been spread of the cancer or not.

The surgeon must be familiar with the methods of spread of cancer. He must be acquainted with the natural history and the biologic aspects of the many kinds of cancer to which the body may be heir. In general, the methods of spread are the following: lymphatic embolism [3]; perineural lymphatic infiltration [4]; lymphatic permeation [5]; blood vessel embolism; invasion through and between neighboring tissues, and travel across serous cavities. It has been difficult to account for metastatic lesions of the brain from tumors of the lung and of the abdominal viscera. It would seem that the capillary beds of the lung and liver would filter out the cells and not allow them to pass cephalad. It has been demonstrated that these metastases take place via the spinal veins which have no valves. On forced inspiration, coughing or retching, the cells are forced into these open venous channels and gain ready access to the cerebral circulation.[6] The lymphatic vessels, in a general way, accompany the blood vessels. The lymph nodes are scattered near the junction points of the branches and tributaries. When the lymphatic vessels are invaded, those nearest the original focus naturally are most likely to receive the metastasis. These regional nodes become involved before there is a generalized spread. This forms the basis for the surgical practice of removal en bloc, in which the primary cancer and its regional nodes are taken in one block of

E. M.: Treatment of Cancer and Allied Diseases, New York, Paul B. Hoeber, Inc., 1940, vol. 3, p. 2488. (*c*) Gall, E. A.: The Surgical Treatment of Malignant Lymphoma, Ann. Surg. **118**:1064-1070, 1943. (*d*) McSwain, B., and Beal, J. M.: Lymphosarcoma of the Gastro-Intestinal Tract, ibid. **119**:108-123, 1944. (*e*) Pasternack, J. G., and Waugh, R. L.: Solitary Myeloma of Bone, ibid. **110**:427-436, 1939. (*f*) Taylor, E. S.: Primary Lymphosarcoma of the Stomach, ibid. **110**:200-221, 1939.

3. Gilchrist, R. K.: Fundamental Factors Governing Lymphatic Spread of Carcinoma, Ann. Surg. **111**: 630-639, 1940.

4. Fraser, J.: Carcinoma of the Floor of the Mouth and Tongue, Ann. Surg. **96**:488-514, 1932. Warren, S.; Harris, P. N., and Graves, R. C.: Osseous Metastasis of Carcinoma of the Prostate with Special Reference to Perineural Lymphosarcoma of the Gastro-Intestinal Tract, ibid. **119**:108-123, 1944. (*e*)

5. Handley, W. S.: Cancer of the Breast and Its Treatment, New York, Paul B. Hoeber, 1922.

6. Batson, O. V.: The Function of the Vertebral Veins and Their Role in the Spread of Metastases, Ann. Surg. **112**:138-149, 1940.

tissue. None of the intervening tissues can be spared but must be sacrificed without hesitation so that no cancer cells will be spilled in the dissection. When the surgeon can remove the cancer and its regional nodes before the disease has progressed beyond the limits of his operation, the patient will be cured.

Block dissection can be applied in cancers of the breast, cancers of the colon and rectum, cancers of the small intestine,[7] cancers of the peripheral parts of the lung, cancers of the thyroid (unilaterally),[8] and, in some instances, in squamous cell carcinomas of the skin and in melanoma malignum.[9] In carcinoma of the gastric antrum an almost complete block dissection is possible. In lesions higher in the stomach the lymphatic drainage is more extensive, and it is difficult to eradicate in one block of tissue. In some cases of lymphosarcoma and Hodgkin's disease radical resection of the involved nodes and of the rest of the chain en bloc has been successful.[2a, b]

Wide primary lateral resections formerly advocated for the carcinomatous lesions of the lips and oral cavity have been abandoned. These radical operations carried a threat to life by opening large areas to infection. It also had been found that this group formed an exception to the rule of block dissection. The intervening tissues between the primary growth and the first lymph nodes rarely showed secondary implants so that such areas could be left behind without the chance for cure being jeopardized. The original intraoral lesions, except for the smaller growths, proved more difficult to eradicate because of anatomic reasons. Surgeons began to leave the outlying nodes until the primary lesion could be brought under control. If the primary lesion could not be eradicated or if it recurred quickly, it was useless to subject the patient to dissection of the glands of the neck. Furthermore, the metastatic trends were not predictable in many cases. As a general rule, in most instances the suprahyoid nodes proved to be the first line of defense, and the deep nodes of the jugular areas were only later developments. The arguments for and against prophylactic dissection of the lymph nodes have waxed and waned according to the convictions of those concerned.[10] The difficulty is that metastasis to

7. Cameron, A. L.: Primary Malignancy of the Jejunum and Ileum, Ann. Surg. **108**:203-220, 1938.

8. (*a*) Crile, G., and Crile, G., Jr.: A Radical Operation for Malignant Tumors of the Thyroid Gland, Surg., Gynec. & Obst. **64**:921-934, 1937. (*b*) Lahey, F. H.; Hare, H. F., and Warren, S.: Carcinoma of the Thyroid, Ann. Surg. **112**:977-1005, 1940.

9. deCholnoky, T.: Malignant Melanoma, Ann. Surg. **113**:392-410, 1941.

10. (*a*) Brown, J. B., and McDowell, F.: Treatment of Metastatic Carcinoma of the Neck, Ann. Surg. **119**:543-555, 1944. (*b*) Kennedy, R. H.: The Management of Lymph Nodes in the Neck Metastatic from Carcinoma of the Mouth,

(*Footnote continued on next page*)

lymph nodes cannot be determined clinically by the methods of physical examination. When the nodes are not palpable or even suspected, there may be a 10 per cent involvement. When the nodes are palpable, the error in the assessment of metastasis runs between 25 and 30 per cent.[11] The mistakes in the latter instance are in both directions, i. e., the examiner thinks that there is involvement and microscopic section fails to show it or vice versa. The old argument was that no chances should be taken but that a prophylactic dissection should be done in every instance. In regard to the nonpalpable nodes such dissection was unnecessary in 9 of 10 cases. On the other hand, when nodes are palpable it is difficult for the surgeon to withhold operation because the chance for error is great. Even when the nodes are involved there is a good five year result in over 50 per cent of cases.

Thus there has arisen gradually another surgical principle for the treatment of cancers of certain regions. First, eradicate the original growth and then remove the regional nodes at a later date, prophylactically in instances in which the malignancy is of a high degree and metastasis is known to be likely and in other cases only after the patient has been closely observed at stated intervals until involvement of the nodes becomes evident. In this way unnecessary dissection of lymph nodes may be avoided.

Cancers which may be treated by this method are squamous cell cancers of the lips, buccal mucosa, gingivae and hard palate and certain squamous cell cancers of the skin. When such primary lesions of the skin are small and of well differentiated nature histologically and when no nodes are palpable, prophylactic dissection may be omitted, especially in cancers of the fingers, hands and trunk and in those of the face, eyelids, nose, scalp, neck and ears. In all these dissection of lymph nodes is optional unless the lesions are large, undifferentiated histologically, recurrent from previous treatment and accompanied with sizable palpable nodes. If they are of this nature, the primary lesion must first be controlled and dissection of the nodes done at a second operation. The local early cure seems to prevent metastasis in a majority of these types of lesions.

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ibid. **114**:813-819, 1941. (*c*) Martin, H.: The Treatment of Cervical Metastatic Cancer, ibid. **114**:972-985, 1941. (*d*) Martin, H.; MacComb, W. S., and Blady, J. V.: Cancer of the Lip, ibid. **114**:226-242 and 341-368, 1941. (*e*) Taylor, G. W., and Nathanson, I. T.: Lymph Node Metastasis, New York, Oxford University Press, 1942, p. 168; (*f*) Evaluation of Neck Dissection in Carcinoma of the Lip, Surg., Gynec. & Obst. **69**:484-492, 1939. (*g*) Taylor, G. W.; Nathanson, I. T., and Shaw, D. T.: Epidermoid Carcinoma of the Extremities with Reference to Lymph Node Involvement, Ann. Surg. **113**:268-275, 1941.

11. Harrington, S. W.: Unilateral Carcinoma of the Breast Treated by Surgical Operation and Radiation, Surg., Gynec. & Obst. **60**:499-504, 1935. Taylor and Nathanson.[10e]

In squamous cell cancers of the skin of the feet, legs or arms and in malignant melanomas, except for those on the trunk, prophylactic dissection of lymph nodes is better done after the primary lesion has been removed. These lesions are so prone to metastasize that unnecessary chances are taken if the nodes are not removed. Suprahyoid dissection bilaterally is advisable also for carcinomas of the antrum, floor of the mouth, soft palate and anterior part of the tongue after the primary lesion has been erased. In cancers of the anus, vulva, vagina, scrotum and penis the patient should be carefully watched every month for evidence of lymph node invasion after the primary lesion is controlled. Bilateral dissection of the groin may be necessary to control the spread if the condition of the patient is good enough to withstand such an ordeal. In malignant melanomas of the trunk there is a possibility of metastasis upward toward the axilla or downward toward the groin, and often it is impossible to gage their spread. Lymphoepitheliomas and transitional cell cancers will require dissection of the lymph nodes usually.

Whenever dissection of lymph nodes is omitted, the surgeon takes on a grave responsibility. He must arrange for a periodic follow-up and examine the regional nodes for evidence of trouble. He must not allow his patient to miss an appointment. This means a date file and a follow-up if the patient fails to appear. The social service workers have a special field of usefulness in this type of endeavor. The frequency of examination is determined by the type of histologic changes, the age of the patient and numerous other factors. After that it becomes a matter of responsibility and thoroughness in order to detect metastasis at the earliest possible moment.

A third type of surgical handling has evolved through clinical experience. Cancers of some types have a low grade of malignancy. Local removal is all that is required in such growths because the likelihood of metastasis is remote. Such cancers of the skin as the basal cell group rarely extend to the lymph nodes. Thorough local removal will cure them. Mixed tumors of salivary glands affecting the parotid, intraoral and cervical regions have a low index of malignancy. Their growth is slow, and recurrence is rare after proper careful removal. The majority of the recurrences, in my opinion, reflect inadequate surgical treatment and a failure to recognize the "collar button" extensions.[12] Many of these parotid tumors which do recur are malignant cancers in the beginning and call for more radical removal at that time. Adamantinomas are a similar group of slowly growing tumors which do not

12. (*a*) Bailey, H.: The Treatment of Tumours of the Parotid Gland, Brit. J. Surg. **28**:337-346, 1941. (*b*) Houck, J. W.: Tumors of the Salivary Glands, Surgery **6**:550-584, 1939. (*c*) Montanus, W. P.: Mixed Tumor of the Parotid Gland with Metastasis, ibid. **4**:423-429, 1938.

recur if removed intact either in their capsules or by resection of the involved bone. Recurrences are slow, and lesions may be removed locally again, with a wider margin. Intrinsic operable cancers of the larynx may be removed by a simple laryngofissure or by a narrow field incision confined to the midline according to the technic of Crowe and Broyles. When the laryngeal cancer becomes extrinsic, it is a different situation. Leiomyomas of the stomach are really benign tumors easily cured by local resection, as are also the gastric polyps and "polyps en nappe." The carcinoids or the argentaffin tumors are slow in their progress, and this includes those which have spread beyond the original focus (25 per cent). Three fourths of these lesions can be removed locally without danger of recurrence from the region of the appendix, cecum and terminal ileum; their bright yellow color helps the surgeon to decide on their nature.[13] Cancer of the body of the uterus is cured by simple hysterectomy in a high percentage of cases. Practically all fibrosarcomas can be handled by simple resection which includes the fascia of the underlying muscle or by removal of the muscle from its origin to its insertion in the same block. This is because only about 5 per cent of them metastasize. They may recur locally several times, often giving the surgeon a number of opportunities to get rid of them. Neurosarcomas offer similar chances even though it is necessary to resect part of a bone to give them a good margin in removal. Meningiomas may be successfully handled by careful dissection even when the overlying bone is widely invaded. The bone flap in such instances can be sacrificed, as tantalum makes a fine substitute for it. Tumors of the peripheral nerves of the spinal cord are usually benign, the symptoms and signs being a result of their anatomic location. The same is true of the neurinomas of the eighth nerve, recurrence being avoided by the complete removal of the capsule.[14] The astrocytomas can be successfully handled if the neurosurgeon recognizes the importance of removing the solid nodules from the wall of the cystic cavity. No recurrence will follow if this step is carefully done. The peculiar fluffy appearance of the calcification in ependymomas and oligodendrogliomas warns the surgeon that he must make a wide exposure. These tumors extend beyond the areas of calcification, and if ample exposure is made it is sometimes possible to excise them in toto by giving them a good margin.[14a] The pearly tumors are benign dermoids and do not

13. Wyatt, T. E.: Argentaffine Tumors of the Gastro-Intestinal Tract, Ann. Surg. **107**: 260-269, 1938.

14. Dandy, W. E.: Removal of Cerebellopontile (Acoustic) Tumors Through a Unilateral Approach, Arch. Surg. **29**:337-344 (Sept.) 1934.

14a. Sachs, E.: Surgery of Brain Tumors Today and Ten Years Ago, Surgery **9**:883-895, 1941.

recur after even partial removal. The surgeon counts himself most fortunate when he exposes this lesion. Finally, surgeons should know about "blue nevi," i. e., benign lesions of typical spindle cell type described by Jadassohn and Tieche.[15] These lesions should be let alone or should be removed locally. The patient should be reassured and not alarmed regarding them.

There are some lesions which biologically call for drastic measures, but surgeons have preferred to try simpler approaches. Resections and amputations for some bone sarcomas of low grade malignancy such as chondrosarcomas, parosteal sarcomas, malignant giant cell tumors or osteogenic sarcomas of highly differentiated types have been done successfully by some surgeons.[16] Bone grafts have been placed to restore the function of the limb.

The surgical approach to a fourth group of malignant lesions may be called that of "last chance" or "desperation" therapy. Cancers in some situations do not lend themselves to removal of the regional areas. This may be due to the presence in the area of important and essential blood channels such as the aorta, the portal vein and the superior mesenteric artery or of both ureters or the bronchi. Radiation therapy as a rule is unfavorable for the internal cancers. There being nothing left to do, the patient and surgeon may prefer to take a gamble that local removal or local and partial regional removal might possibly succeed. A certain number of the patients survive, and there is no recurrence or metastasis. This is a rather flimsy basis for procedure, but it does offer some hope and is preferable to condemning the patients to certain death without a chance for a fight. For instance, some tumors are notorious for their rapid general spread through the body by means of the blood stream, the lymphatic vessels or both. The hypernephromas are an example of lesions in which widespread metastasis to the pulmonary fields, the long bones, the scapula and the skull (often as pulsating tumors) and to bizarre locations such as the tip of the tongue (Strong Memorial Hospital case 210769), the axilla and the parotid region makes it exceedingly unlikely that the surgeon can offer any help. Yet in some cases simple nephrectomy has resulted in cure, and in others metastasis does not occur for many years after such an operation. In the latter it even seems worth while to remove the metastatic focus as it may represent the only tumor tissue remaining in the body.

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15. Montgomery, H., and Kahler, J. E.: The Blue Nevus (Jadassohn-Tieche): Its Distinction from Ordinary Moles and Malignant Melanomas, Am. J. Cancer **36**:527-539, 1939.

16. Coley, B. L., and Pool, J. L.: Factors Influencing the Prognosis in Osteogenic Sarcoma, Ann. Surg. **112**:1114-1128, 1940. Phemister, D. B.: Conservative Surgery in the Treatment of Bone Tumors, Surg., Gynec. & Obst. **70**: 355-364, 1940.

A 58 year old man entered the hospital with a large tumor mass in the right femur (Strong Memorial Hospital case 212059). Sixteen years previously he had a hypernephroma removed with his right kidney. Amputation of the hip joint was done. The microscopic examination showed typical hypernephroma tissue in the femur. Four years later he was getting about well on an artificial limb, without evidence of metastatic tumor anywhere.

The Wilms tumor in babies is a similar unfavorable type which may be cured by simple nephrectomy.[17] Life is saved in occasional cases of osteogenic sarcomas, Ewing's tumor of bone,[18] chondrosarcoma [12c] and synovial sarcoma [19] by early amputation well above the lesions. Soma ovarian tumors with widespread peritoneal implants are cured by ovariectomy. Castration may be all that is necessary to rescue some patients with testicular tumors and even a rare one with prostatic carcinoma. Patients with tumors of the upper part of the thigh such as rhabdomyosarcomas, liposarcomas and tumors of the femur and those with tumors of the pelvic bones have been given a chance for life by the formidable hindquarter resection advocated by Gordon-Taylor.[20] Even lymphosarcomas may be removed successfully in the early stages before general spread has taken place.[2a,b] The anatomic difficulties are almost insurmountable in the treatment of malignant growths in some locations. Primary cancer of the liver can rarely be removed because of the ducts and vessels involved. The central cancers of the lung are usually beyond surgical help. The mediastinal nodes are too scattered through the hilar regions to allow dissection. And yet surgeons have successfully removed cancers of the peripheral parts of the lung by lobectomy or preferably by unilateral pneumonectomy. The middle and lower parts of the esophagus posed the difficulty of restoration of the gastrointestinal tract if their relatively late metastasizing cancers were removed. Surgeons learned how to make this anastomosis successfully by approaching these tumors through the chest and by bringing the stomach up through the diaphragm as high as the aorta if neces-

17. Ladd, W. E.: Embryoma of the Kidney (Wilms's Tumor), Ann. Surg. **108**:885-902, 1938.

18. Morton, J. J.: The Treatment of Ewing's Sarcoma of Bone, in Pack, G. T., and Livingston, E. M.: Treatment of Cancer and Allied Diseases, New York, Paul B. Hoeber, Inc., 1940, vol. 3, pp. 2422-2436.

19. Briggs, C. D.: Malignant Tumors of Synovial Origin, Ann. Surg. **115**: 413-426, 1942. Moretz, W. H.: Malignant Tumors Arising from the Synovial Membrance with Report of Four Cases, Surg., Gynec. & Obst. **79**:124-132, 1944.

20. Gordon-Taylor, G.: Further Review of Interinnomino-Abdominal (Hind Quarter) Amputation: Eleven Personal Cases, Brit. J. Surg. **27**:643-650, 1940. Morton, J. J.: Interinnomino-Abdominal (Hindquarter) Amputation, Ann. Surg. **115**:628-646, 1942.

sary.[21] Most cancers of the stomach are too advanced to be successfully removed surgically in spite of the extension of the operation to include total gastrectomy.[22] Cancers of the gallbladder have inaccessible nodes, and it is pure chance when one is successfully removed.[23] Cancers of the ampulla, the duodenum and the head and body of the pancreas have been removed by the approach practiced by Whipple and others [24] when once it was found that the pancreas could be resected or removed in toto if necessary. In these operations there are many technical problems in restoration of the ducts and of the gastrointestinal tract. The portal vein and the wide lymphatic drainage add to the difficulties in securing good results.[25] Cancers of the cervix were for a period treated surgically when the Wertheim operation was in its heyday.[26] It was considered too difficult a dissection, and radiation treatment gradually took the lead until recently. Now the Wertheim operation is being revived.[27] It fails as a complete block dissection because of the ureters. It is there that difficulties in the operation keep it from being ideal. Some cancers of the bladder can be removed only after both ureters have been transplanted into the sigmoid. By these maneuvers it has been possible to save some patients with this lesion.[28] The radical resection of prostatic cancer according to Young's operation is useful and promising when the cancer has not invaded the capsule and become fixed.[29] Castra-

21. Churchill, E. D., and Sweet, R. H.: Transthoracic Resection of Tumors of the Stomach and Esophagus, Ann. Surg. **115**:897-920, 1942. Clark, D. E.: Transthoracic Esophagogastrostomy for Carcinoma of the Middle Third of the Esophagus, ibid. **121**:65-73, 1945. Garlock, J. H.: The Surgical Treatment of Carcinoma of the Thoracic Esophagus, Surg., Gynec. & Obst. **66**:534-548, 1938.

22. Graham, R. R.: A Technique for Total Gastrectomy, Surgery **8**:257-264, 1940. Lahey, F. H., and Marshall, S. F.: Indications for and Experience with Total Gastrectomy, Ann. Surg. **119**:300-320, 1944. Ogilvie, W. H.: Cancer of the Stomach, Surg., Gynec. & Obst. **68**:295-305, 1939. Parsons, L., and Welch, C. E.: The Curability of Carcinoma of the Stomach, Surgery **6**:327-338, 1939.

23. Lam, C. R.: The Present Status of Carcinoma of the Gallbladder, Ann. Surg. **111**:403-410, 1940. Lichenstein, G. M., and Tannenbaum, W.: Carcinoma of the Gallbladder, ibid. **111**:411-415, 1940.

24. Whipple, A. O.; Parsons, W. B., and Mullins, C. R.: Treatment of Carcinoma of the Ampulla of Vater, Ann. Surg. **102**:763-779, 1935.

25. Whipple, A. O.: The Rationale of Radical Surgery for Cancer of the Pancreas and Ampullary Region, Ann. Surg. **114**:612-615, 1941.

26. Bonney, V.: Treatment of Carcinoma of Cervix by Wertheim's Operation, Am. J. Obst. **30**:815-830, 1935. Taussig, F. J.: Iliac Lymphadenectomy with Irradiation in the Treatment of Cancer of the Cervix, Am. J. Obst. & Gynec. **28**: 650-667, 1934.

27. Meigs, J. V.: Carcinoma of the Cervix: The Wertheim Operation, Surg., Gynec. & Obst. **78**:195-199, 1944.

28. Hinman, F., and Smith, D.: Total Cystectomy for Cancer, Surgery **6**: 851-881, 1939.

29. Colston, J. A. C.: Carcinoma of the Prostate, J. A. M. A. **134**:848-852 (July 17) 1947.

tion is an alternative method of treatment of cancers of the prostate.[30] Carcinomas of the adrenal cortex may be slow to recur after simple adrenalectomy or a few may be cured. The neuroblastomas of children have never been treated successfully by surgical intervention as their spread is too rapid either through the lymph nodes to the mediastinum, pharynx, orbits and skull or into the liver. Ovarian tumors are unpredictable, but they are usually of such a high grade of malignancy that end results are unfavorable. Many patients with tumors handled partially by surgical intervention can be treated fairly successfully by supplementation with radiation therapy. A discussion of this would constitute a chapter in itself.

There is an additional group for which "last chance" surgical treatment is given, namely, those basal cell cancers which have invaded the antrum or orbit and which do not respond to radiation therapy. A wide destructitve operation, in which the antrum is unroofed and the eye removed, may lead to cure. The patient must be watched for recurrences for a period, and plastic repair will then be necessary later. Skin will have to be brought in from an area not exposed to radiation as the viability of irradiated skin is notoriously uncertain.

The principle of prevention of cancer can be applied through surgical removal of lesions which are likely to become cancerous. The adenomas of the thyroid [31] and the lateral aberrant thyroid nodules [32] have been considered precancerous lesions for many years. Their removal is relatively easy in the benign state. Polyps of the colon and rectum are frequent precursors of carcinomas. Removal of these benign lesions is good preventive medicine and should be encouraged. Wangensteen has discovered and removed a number of polypoid lesions in the stomach by routine investigation of persons with anacidity. The papillary cystadenoma of the breast is a lesion which is hyperplastic and frequently difficult to evaluate. Keratoses of the skin of the face and hands and similar lesions due to arsenic and to roentgen ray exposure should be removed before they progress to malignancy. The same treatment should be advocated for many benign melanomas, sebaceous cysts, Bowen's disease and extramammary Paget's disease. Long-standing or repeatedly recurring ulcerations in scars and burns due to ischemic necrosis should be excised and skin grafted before malignant degeneration takes place. Papillomas of the lips and tongue and raised thickened patches of leukoplakia demand surgical attention before malignancy supervenes. Polyps of the nasal passages, papillomas of the larynx and ulcerations about

30. Huggins, C.: Prostatic Cancer Treated by Orchidectomy: The Five Year Results, J. A. M. A. **131**:576-581 (June 15) 1946.

31. Brenzier, A. G., and McKnight, R. B.: True Adenomas of the Thyroid Gland and Their Relation to Cancer, Tr. Am. A. Study Goiter, 1940, pp. 176-190.

32. Cattell, R. B.: Aberrant Thyroid, J. A. M. A. **97**:1761-1767 (Dec. 12) 1931.

the eustachian tube are better treated surgically as soon as possible. Adenomas of the bronchial tubes should be cared for.[33] Cysts and fistulas about the head and neck, especially those in the branchial cleft zones, must not be allowed to remain. Papillomas of the bladder, polyps of the uterus and caruncles of the urethra should be removed before they progress to an unfavorable degree. Epulides, many exostoses, chondromas and giant cell tumors of bone offer opportunities for preventive surgical therapy. Long-standing gallstones and stones in the kidneys and bladder could conceivably be chronic irritants which might set off the malignant reaction in the cells. Aberrant rests of heterotopic nature should be removed when encountered. Circumcision has been demonstrated as a practical preventive treatment against the future development of penile carcinoma.[34] Leukoplakia of the vulva is a dangerous lesion requiring surgical removal.[35]

Another instance when surgical treatment may be used to advantage is when palliation is necessary. Surgeons have had to deal with advanced cancer for many years, and during that time they have been forced to learn how to add to the comfort of their patients. There are many ways in which operation can give relief. Obvious ulcerating lesions of the skin, parotid or breast can be excised even though metastasis has occurred. The area will heal, no dressing will be necessary and the infection will be controlled and the loss of serum and blood prevented. The same holds true for ulcerating carcinomas anywhere in the gastrointestinal tract. Formerly when metastasis was found at operation nothing was attempted with the primary growth. There has been a change of late to a more radical attitude, and now it is considered good surgical practice to remove these primary foci whenever possible without undue risk. For example, in rectal carcinoma an abdominal-perineal resection often provides a comfortable terminal existence though there is some metastasis to the liver. The postoperative course is much better, the irritating, seeping and infected areas are removed and the function of the bowel becomes normal again. In obstructing lesions palliative operations are useful when the growths are fixed and not resectable. Simple gastroenterostomy, enterostomy, enterocolostomy or colocolostomy all give comfort by relieving crampy pains, distention, constipation, diarrhea and tenesmus. Internal anastomoses are preferable to external drainage whenever feasible. However, relief of jaundice by external drainage of the gallbladder or common duct in some circumstances is exceedingly useful as palliation or as a first stage to

33. Adams, W. E.; Sterner, P. E., and Bloch, R. G.: Malignant Adenoma of the Lung, Surgery **11**:503-526, 1942.

34. Kennaway, E. L., and Kennaway, N. M.: The Social Distribution of Cancer of the Scrotum and Cancer of the Penis, Cancer Research **6**:49-53, 1946.

35. Sparrow, T. D.: Leukoplakic Vulvitis, Ann. Surg. **112**: 87-99, 1940.

resection. Similarly, gastrostomy may save a patient from starvation, tracheotomy may relieve him from asphyxia and colostomy may rid him of frequency, dysuria and tenesmus. The handling of these artificial openings requires careful attention to details, but with proper training the disagreeable features can be minimized and even brought to habit regulation. It is a great satisfaction to bring relief to a patient even for a period of months, and sometimes it is surprising how long patients will live in comfort with known metastasis to the liver. I have known a patient with gastric carcinoma in such circumstances to survive in perfect comfort for five years after a posterior gastroenterostomy was done and a patient with carcinoma of the colon in whom a resection and end to end anastomosis was done in similar circumstances to survive for seven years. Finally, there is the possibility of surgical relief from pain. If the painful areas can be sharply localized, relief may be given by section of the proper cranial nerves or the posterior roots or by chordotomy. In some instances also there may be need for resection of the sympathetic nerves. The relief afforded in this way is often dramatic.

The most striking palliative relief is experienced when castration is used for advanced carcinomas of the prostate. Huggins proposed this measure, and there has been almost unanimous agreement as to its efficacy. Within twenty-four hours, with a few exceptions, pain disappeared. No further opiates were necessary. There was improvement in energy and well-being. Patients ate better and gained weight. Some who were bedridden recovered the use of their paralyzed limbs. The destructive areas in the bones filled in with new bone. Enlarged lymph nodes, presumably with cancer in them, receded and could no longer be felt. Metastatic nodules in the pulmonary fields got smaller and even disappeared from roentgenograms of the chest.[36] The nodules in the prostate smoothed down so that the gland seemed normal to palpation. Residual urine lessened in amount, and infection tended to clear up. This palliative effect varied in time; some patients even have remained well for several years.[37] The majority, however, had relapses and recurrence of symptoms after six months to two years. All told, however, this palliation is worth while for men whose life expectancy at the time is not too great. Castration has been used for carcinoma of the male breast, and here again the results are promising.[38] It has been known for years that bilateral oophorectomy has been followed by

36. Alyea, E. P., and Henderson, A. F.: Carcinoma of the Prostate, J. A. M. A. **120**:1099-1102 (Dec. 5) 1942.

37. Huggins, C., and Hodges, C. V.: Studies on Prostatic Cancer, Cancer Research **1**: 293-297, 1941. Huggins.[30]

38. Farrow, J. H., and Adair, F. E.: Effect of Orchidectomy on Skeletal Metastases from Cancer of the Male Breast, Science **95**:654, 1942.

remarkable improvement in some cases of breast cancer in the premenopausal group. Temporary improvement may be expected in about one third of the patients with recurrent or inoperable cancer.[39] The results are similar to those obtained in prostatic cancer in that pain lessens, the patient feels remarkably better, the appetite improves, there is gain in weight and strength, the bone lesions heal and recurrent nodules disappear. Palliation for the headaches accompanying tumors of the brain has been possible through decompression operations or by tapping through burr holes over the dilated ventricles.

By trial and error and by careful observation surgeons have learned how to judge operability in cases of cancer. Rules for the younger surgeons are passed on by their predecessors and emphasized whenever opportunity presents. Resectability has been extended by daring operations in which portions of other organs have been included in the block of tissue, with repair or with restoration of the continuity. Thus lesions adherent to the bladder, the liver or the small or large bowel have been removed with success. This has become possible as surgeons have learned to be careful of hemostasis and gentle with their handling of tissue. The methods of restoring blood volume, combating infection, preventing shock and exercising care in the preoperative and postoperative periods have led to feats of surgery undreamed of in the past.[40]

There are some rules of inoperability which still obtain and which surgeons would do well to heed. Cancer of the breast is considered inoperable when it is fixed to the chest wall, when it is massive, involving almost the whole breast with edematous tissues, when there are numbers of scattered skin nodules, when there are enlarged hard supraclavicular nodes, when there is swelling of the arm, when there is visceral or osseous metastasis and when it is an inflammatory carcinoma. In addition to this it is inoperable when the carcinoma develops during pregnancy or lactation, when there is ulceration of the skin and when there is fixation of the axillary lymph nodes to the skin or deep structures of the axilla proved to contain metastatic lesions by biopsy.

39. Nathanson, I. T.: The Relationship of Hormones to Diseases of the Breast, Surgery **1**:108-140, 1944.

40. Bowers, R. F.: Surgical Treatment of Malignant Lesions of the Sigmoid with Extensions, Ann. Surg. **115**:986-995, 1942. Brunschwig, A., and Morton, D. R.: Resection of Abdominal Carcinomas Involving the Liver and Spleen Secondarily, ibid. **124**:746-754, 1946. Brunschwig, A.: Radical Resections of Advanced Intra-Abdominal Cancer, ibid. **122**:923-932, 1945. David, V. C., and Gilchrist, R. K.: Extension of the Border Line of Operability in Cancer of the Rectum, ibid. **115**:566-573, 1942. Lahey, F. H.: Total Gastrectomy, Splenectomy, Resection of the Left Lobe of the Liver, Omentumectomy and Colectomy upon One Patient in One Operation, ibid. **119**:222-224, 1944. Sugarbaker, E. D.: Coincident Removal of Additional Structures in Resections for Carcinoma of the Colon and Rectum, ibid. **123**:1036-1046, 1946.

Haagensen and Stout [41] have never seen a permanent cure following operation in these circumstances. When primary cancers of the intraoral or cutaneous regions cannot be cured by surgical intervention or by irradiation it is useless to dissect the regional lymph nodes draining such areas. These recurrent lesions will almost certainly metastasize by some channels even if the regional lymph nodes have been removed. Also when the nodes are fixed, when they invade the muscles and the great vessels, when there are extracapsular involvement and matting and when there is multiple and distant metastasis, the cancer is inoperable. Inaccessibility of involved nodes constitutes another situation in which operative removal is not curative. This may occur with the nodes of esophageal cancer, cancer of the lung, or gastric cancer, in which the chain is along the superior mesenteric vessels. Widespread dispersion of nodules throughout the peritoneal or pleural cavities must be added to this list. Growths fixed to the parietes or "frozen" in the pelvis in such a way that the surgeon cannot get around them into noninvolved tissues are hopeless as far as removal is concerned.

There are certain principles applicable to all surgery, and surgical treatment for cancer is no exception. First of all, the surgeon must be grounded in the reaction of tissues to injury, in asepsis and antisepsis, in the fundamentals of refined technic, in the preoperative and postoperative preparations necessary to avoid reactions, in the treatment of shock and of unexpected complications and in the use of the antibiotics. In other words, he should be a good general surgeon even though he may specialize in a limited field later. He must consider his patient and strive to return him to a condition of useful living. It is not too difficult under the present advantages to remove some cancers by extensive procedures, but if the patient then remains marred physiologically or a burden to his family the treatment has not been successful. The surgeon must learn that there are many things to be considered in addition to the mechanical removal of diseased tissue. The restoration of the organs as near to their proper functions as possible is a goal to be desired. An understanding of the many and varied pathologic types of cancer may help him to evaluate his chances of successful treatment and assist him in his prognosis. It is well for him to know that some forms of cancer are highly malignant while others are exceedingly slow in growth. He should not be so enthusiastic over his therapy that he becomes "one sided" and fails to recognize that in some cases radiation therapy is as desirable as surgical intervention or better. When he has decided on operation, it should be well planned, careful and thorough. There should be no compromise with cancer, and tissues will have to be sacrificed

41. Haagensen, C. D., and Stout, A. P.: Carcinoma of the Breast, Ann. Surg. **116**:801-915, 1942; **118**:859-870 and 1032-1051, 1943.

when necessary. The surgeon should never tie his hands by committing himself to a promise to the distracted patient or relatives before operation. These persons should have trust in their surgeon's training and should rely on his judgment, which is surely bound to be better than their own. The surgeon should not be positive in his diagnosis and prognosis without microscopic evidence. He will save himself embarrassment by waiting for the sections, and many of the "cures" by quacks will thus be annulled.

A 73 year old minister entered the hospital in June 1936 (Strong Memorial Hospital case 115745). His history appeared to indicate that he had gastric carcinoma, and at exploration a mass was found on the posterior pyloric end of the stomach. What appeared to be metastatic lesions were present in the gastrohepatic ligament. A biopsy was taken of one of the lesions and closure made as it seemed to be an inoperable condition. He was discharged from the hospital with the impression that he had advanced cancer and that the outlook was hopeless. He went as soon as he could to a quack cancer clinic in a neighboring city. In the meantime the microscopic sections showed peculiar embryonic rests, with no evidence of cancer. He improved in health and became a fanatic advocate of the cancer cure. Nothing could shake his faith or devotion to this cause.

The surgeon should not give up a case as hopeless until he is sure. Many times it becomes possible to resect a lesion which appeared at first to be impossible of resection. Deeply fixed growths, however, are rarely operable, and digging them out is not good surgical practice. Radical operation should be done even in older persons if it is well considered because age is no longer a bar to careful surgical treatment. It should be remembered that growth is much slowed in the aged and that radical operation may not be necessary. Cancer of the breast, for instance, appears to behave like a different lesion in women beyond 70 years. I have a small series of such patients who have done exceptionally well for years after simple mastectomy. The same is true for some types of small polypoid carcinomas of the rectum for which local removal or radium implants have been successful. These decisions place a big responsibility on the surgeon, and he must know when to make the exceptions to the rules.

ROLE OF SPLENECTOMY IN THROMBOPENIC PURPURA

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IDIOPATHIC thrombopenic purpura is a symptom complex characterized by petechial hemorrhages, thrombopenia, impaired clot retraction and prolonged bleeding time. Widespread internal hemorrhages may occur and cause the death of the patient. The symptom complex is frequently encountered, but the more seriously affected patients are comparatively rare.

Although Werlhof [1] is generally considered as having described this disease first, in 1775, it was Brohm [2] who, in 1883, first observed thrombopenia in a case of purpuric disease. It has been assumed that Werlhof's patient had thrombopenia; hence, the disease bears his name. Interest has centered chiefly on the role of blood platelets in this disease.

The existence of platelets was recognized by several workers in the early nineteenth century, but for many years their existence as real or as artificial blood elements was in controversy. It was the result of the collective researches of Zimmerman,[3] Schultze,[4] Osler,[5] Bizzozero [6] and Hayem [7] that it became known that the platelets are part of the formed elements of the peripheral blood and that they are concerned with intravascular clotting. Both Hayem and Bizzozero

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1. Werlhof, P. G.: Opera medica, Paris, J. E. Wichmann, 1775, p. 748.

2. Brohm, cited by Quick.[24]

3. Zimmerman, G.: Ueber die Formgebilde des menschlichen Blutes, Mag. f. d. ges. Heilk. **66**:171, 1846.

4. Schultze, M.: Eim heizbarer Objetisch und seine Verwendung bei Untersuchungen des Blutes, Arch. f. mikr. Anat. **1**:1, 1865.

5. Osler, W.: An Account of Certain Organisms Occurring in the Liquor Sanguinis, Proc. Roy. Soc., London **22**:391, 1874.

6. Bizzozero, G.: Ueber einen neuen Formbestandteil bes Blutes, Virchows Arch. f. path. Anat. **90**:261, 1882.

7. Hayem, G.: Leçons sur des maladies du sang, Paris, Masson & Cie., 1900.

demonstrated that the first noticeable histologic change which followed injury to the vascular endothelium was the deposition, agglutination and, finally, disintegration of platelets at the point of endothelial injury. It was also noted that fibrin needles made their appearance so quickly after the platelet thrombus formed that it was difficult to be certain that the thrombus formation had actually preceded the appearance of fibrin. Hayem,[7] in particular, realized the importance of the platelet as an essential part of the normal hemostatic mechanism and, in 1882, predicted that platelet deficiency might result in hemorrhagic disease.

The megakaryocytic origin of platelets was proposed by Wright,[8] who presented a series of photomicrographs depicting the pseudopodial disintegration of megakaryocytes. Wright observed fragments of these pseudopods entering sinusoids of marrow spaces and called attention to the similarity in the staining qualities of the megakaryocytes and of the platelets. Most writers on the subject, including Howell[9] and Morawitz,[10] have stated the belief that the initiation of coagulation is largely dependent on the release of thromboplastin when platelets disintegrate.

PATHOLOGY

The pathologic features of thrombopenic purpura were described by Karsner[11] as (1) a slight increase in the megakaryocytes and normoblasts in the marrow, (2) hyperplasia and necrosis of the splenic follicles and (3) hemorrhagic manifestations. Much attention has been devoted to the spleen; yet these studies have been relatively fruitless. In many instances the spleen appears normal microscopically. Occasionally slight fibrosis, some edema or evidence of recent or of old focal hemorrhages is observed. The consensus among observers is that the pathologic picture is a disappointing contrast to the sometimes dramatic clinical course.

Other observations that relate to the pathology of thrombopenic purpura have been made on the marrow. When hemorrhage occurs, from whatever cause, the marrow is stimulated. This results in a general hyperplasia of the erythroid, myeloid and megakaryocytic elements of the marrow.

In thrombopenic purpura not associated with active hemorrhage, erythroid and myeloid hyperplasia is slight. The megakaryocytes con-

8. Wright, J. H.: The Origin and Nature of the Blood Plates, Boston M. & S. J. **154**:643, 1906.

9. Howell, W. H.: The Nature and Action of the Thromboplastic (Zymoplastic) Substance of the Tissues, Am. J. Physiol. **31**:1, 1912.

10. Morawitz, P.: Beiträge zur Kenntnis der Blutgerinnung, Deutsches Arch. f. klin. Med. **79**:1, 1903-1904.

11. Karsner, H. T.: Human Pathology, ed. 6, Philadelphia, J. B. Lippincott Company, 1942.

tinue to be numerous, however. It has been noted[12] that the megakaryocytes in purpura tend to be relatively young. The condition of the marrow may return to normal after splenectomy.[12] When splenectomy is unsuccessful and hemorrhage continues, the changes in the marrow may persist. It is difficult to determine which part of the change in the bone marrow results from hemorrhage and which part represents the primary disorder.

PRESENTATION OF CLINICAL CASES

The diagnosis of idiopathic thrombopenic purpura was established in the cases of 20 patients admitted to the University of Chicago Clinics during the past twenty years. Thirty-two other patients who had symptomatic thrombopenic

Results of Medical Vs. Surgical Treatment of Thrombopenic Purpura

Case	Age	Sex	Symptom	Initial Platelet Count	Results
			Medically Treated Patients		
1	6 yr.	M	Frequent bruising	30,000	No bleeding in 7 yr.
2	14 mo.	M	Bleeding, several days	80,000	No bleeding in 6 mo.
3	1 mo.	F	Bleeding, 1 wk.	40,000	No bleeding in 2 yr.
4	6 yr.	F	Vaginal bleeding, 1 wk.	70,000	No bleeding in 2 yr.
5	7 yr.	F	Oral bleeding, 24 hr.	50,000	No bleeding in 2 yr.
6	36 yr.	F	Epistaxis, 2 yr.	90,000	No bleeding in 2 yr.
7	41 yr.	F	Epistaxis, 3 mo.	90,000	Recurrence
8	50 yr.	F	Menorrhagia, several years	65,000	Same petechiae
9	9 yr.	M	Epistaxis, 5 days	35,000	No bleeding in 2 yr.
10	22 yr.	F	Petechiae, 4 wk.	12,000	Recurrence
			Surgically Treated Patients		
11	20 yr.	F	Petechiae, 2 mo.	130,000	No bleeding in 5 mo.
12	47 yr.	F	Menorrhagia, 3 yr.	68,000	Recurrence after 1 mo.
13	9 yr.	F	Epistaxis, 7 wk.	95,000	Good after 2 mo.
14	5 yr.	M	Bruising, 4 yr.	80,000	No bleeding in 5 yr.
15	2 yr.	F	Epistaxis, 3½ mo.	65,000	Slight epistaxis after 16 mo.
16	3½ yr.	M	Bruises, 1½ yr.	50,000	Recurrence after 1 yr.
17	21 yr.	F	Petechiae, 4 yr.	60,000	Recurrence
18	9 yr.	F	Petechiae, 6 mo.	32,000	Recurrence after 7 mo.
19	33 yr.	F	Epistaxis, 8 yr.	80,000	Postoperative death
20	37 yr.	F	Ecchymosis, 5 mo.	96,000	Occasional ecchymosis in 2 yr.

purpura secondary to other disease were also examined during this period. Data pertinent to the group studied are shown in the table.

Of this small group, 15 were girls or women. Fourteen of all patients were 22 years of age or younger. Ten of these patients were treated by splenectomy when bleeding persisted despite conservative measures. The remaining 10 patients were treated entirely by medical means. Uncontrolled bleeding was the chief indication for splenectomy. It is noteworthy that the platelet counts were comparable in the medically treated and in the surgically treated group.

The results of medical supportive therapy appear to have justified its use. Only 3 of the 10 patients so treated were known to have recurrences. The recurrences were present only in the older patients, in none of whom were they severe. The follow-up periods ranged from six months to two years.

Less satisfactory results were encountered in the 10 patients subjected to splenectomy. Six of these patients had a recurrence within one month to two

12. Dameshek, W., and Miller, E. B.: Megakaryocytes in Idiopathic Thrombocytopenic Purpura, Form of Hypersplenism, Blood **1**:27 (Jan.) 1946.

years; in 2 of these patients it was severe. The recurrences developed irrespective of age. The length of the follow-up period for these patients was comparable to that of the group treated medically. There was 1 operative death in this group.

TREATMENT

The results of splenectomy in cases of this disease vary considerably in different clinics. The variable course of idiopathic thrombopenic purpura, characterized by its spontaneous remission and exacerbations, necessitates a prolonged follow-up period of years in order that any therapeutic procedure may be properly evaluated. The follow-up period in most of the reported cases, including our own, is too inadequate to permit a sound evalution of splenectomy in treatment of this disease. Favorable results have been reported by many observers.[12] On the other hand, there are workers who report equally satisfactory results from medical management[14]; some of these have also reported a high degree of recurrence following splenectomy.[14a]

The data on results obtained with medical and surgical treatment by different workers are presented in the following tabulations. In 1936, Brown and Elliott[15] recorded good results from splenectomy, as follows:

Result	Splenectomy	No Splenectomy
Complete arrest	4	3
Marked improvement	4	0
Improvement	1	2
No improvement	0	5
Death	1	1

Vaughan and Wright,[16] in 1939, summarized the results in 59 cases, followed from five to fifteen and a half years, and concluded that in the great majority of the cases there was complete relief from symptoms and that the remissions had been permanent to the end of the observation period. Of 6 of their own patients with thrombopenic purpura, observed from ten to fifteen and a half years after splenec-

13. Wintrobe, M. M.; Hanrahan, E. M., Jr., and Thomas, C. B.: Purpura Haemorrhagica, with Special Reference to Course and Treatment, J. A. M. A. **109**:1170 (Oct. 9) 1937. Doan, C. A.; Curtis, G. M., and Wiseman, B. K.: Hemolytopoietic Equilibrium and Emergency Splenectomy, ibid. **105**:1567 (Nov. 16) 1935. Elliott, R. H. E., Jr.: Revaluation of Splenectomy in Thrombocytopenic Purpura, Proc. Inst. Med. Chicago **16**:330 (March 15) 1947. Eliason, E. L., and Ferguson, L. K.: Splenectomy in Purpura Hemorrhagica, Ann. Surg. **96**:801 (Nov.) 1932.

14. (*a*) McLean, S.; Kreidel, K., and Caffey, J.: Hemorrhagic Thrombocytopenia in Childhood, J. A. M. A. **98**:387 (Jan. 30) 1932. (*b*) Diamond, cited by Eliason, E. L., and Stevens, L. W.: Surgery of Spleen in Blood Dyscrasias, Surgery **13**:177 (Feb.) 1943.

15. Brown, D. N., and Elliott, R. H. E.: Results of Splenectomy in Thrombocytopenic Purpura, J. A. M. A. **107**:1781 (Nov. 28) 1936.

tomy, all continued to be free from bleeding phenomena at the time of the report, and 4 of these had normal platelet levels.

Wintrobe [17] summarized the data in 151 cases as follows:

	Medical Treatment		Splenectomy	
	Number	Per Cent	Number	Per Cent
Results of treatment during first episode				
Immediate results				
Recovery	33	61.1	19	79.2
Improvement	19	35.2	..	....
Death	2	3.7	5	20.8
Totals	54	100.0	24	100.0
Late results				
Continued (over four years)	8	17.0	13	76.5
Continued recovery (under four years)	6	12.8	3	17.7
Symptoms or signs in varied degree	33	70.2	1	5.8
Totals	47	100.0	17	100.0
Results of treatment during or after later episodes				
Continued recovery (over four years)	5	22.7	34	46.6
Continued recovery (under four years)	3	13.6	9	12.3
Symptoms or signs in varied degree	10	45.5	22	30.1
Death	4	18.2	8	11.0
Totals	22	100.0	73	100.0

These data indicate that the chances for continued recovery following conservative or medical treatment were less than 1 in 3. After successful splenectomy, on the other hand, the chances for continued recovery were almost 3 in 4 when there had been only one episode of bleeding and somewhat better than 1 in 2 when several episodes had occurred before operation. Wintrobe and his associates stated the belief that recurrence may be associated with accessory spleens.

Giffin [18] reported that from March 7, 1923 to Jan. 1, 1927, at the Mayo Clinic, splenectomy was performed on 20 patients with thrombopenic purpura. The observation period after operation was between five and nine years. There was no operative mortality. Thirteen of the 20 patients had the chronic moderately severe type of the disease; 3 were operated on during an acute exacerbation of the chronic disease; 3 were in the incipient stage of the acute disease, and 1 was in the incipient stage of the moderately severe form. All of these patients were living and in good or fair health without recurrence except for 1 patient who had died of a recurrence of severe metrorrhagia at puberty, five years after splenectomy. The 3 patients operated on during acute exacerbations of the chronic disease were well nine, six and five years respectively after splenectomy. The 3 patients with the

16. Vaughan, S. L., and Wright, T.: Purpura Haemorrhagica, with Especial Reference to Permanence of Remission Following Splenectomy, J. A. M. A. **112**:2120 (May 27) 1939.

17. Wintrobe, M. M.: Clinical Hematology, Philadelphia, Lea & Febiger, 1942, p. 623.

18. Giffin, H. Z.: Essential Thrombocytopenic Purpura, Tr. A. Am. Physicians **47**:218, 1932.

incipient acute type of the disease, operated on during the first attack, were well six and a half, five and a half and five years respectively after operation; the patient with incipient disease of moderate severity was found to have pulmonary tuberculosis three years after operation, and four and a half years after operation this patient apparently was cured.

In 1927 Spence [19] published the results of splenectomy in 101 cases of thrombopenic purpura. He found good results, with no recurrence of hemorrhage, in 69 cases, and in 6 cases there was considerable improvement; in 21 cases death followed the operation, while in 5 cases the hemorrhages continued, with but slight improvement. He summarized his results as follows:

	Acute Type	Chronic Type	Unclassified
Good results			
No recurrence	2	61	6
Improvement	0	6	0
Poor results	0	5	0
Deaths	10	8	3

Whipple,[20] in 1926, collected 81 cases and reported deaths in 6 of the 73 cases of the chronic type and in 7 of the 8 cases of the acute type in which operation was performed. Of the 61 cases in which follow-up studies were made, the results were good in 51, fair in 4 and poor in 6.

In 1935, Pemberton [21] recorded 57 cases of patients treated with splenectomy and stated that splenectomy often had proved a life-saving measure by initiating almost immediate remission of the disease; in 35 of the cases this remission was permanent. In 20, the remission was followed by one or more episodes of mild bleeding. In only 1 case did the disease recur in the acute form. The operative hazard in the chronic form of moderate severity was nominal, and in the incipient acute and recrudescent acute forms the mortality rate was 18 per cent.

COMMENT

One of the important aspects of idiopathic thrombopenic purpura is the relationship between the platelet count and the bleeding tendency. There has been much speculation about a critical platelet level. It has been variously estimated to be from 70,000 to 100,000 per cubic millimeter of blood. There is some evidence, however, that this is not the sole criterion of bleeding.

19. Spence, A. W.: Results of Splenectomy for Purpura Haemorrhagica, Brit. J. Surg. **15**:466 (Jan.) 1928.

20. Whipple, A. O.: Splenectomy as a Therapeutic Measure in Thrombocytopenic Purpura Haemorrhagica, Surg., Gynec. & Obst. **42**:329, 1926.

21. Pemberton, J. de J.: Diagnosis and Treatment of Purpura Hemorrhagica, Proc. Staff Meet., Mayo Clin. **9**:532 (Sept. 5) 1934.

Case 10 (fig. 1) in our series is a good example of the fact that the platelet count may remain low while the patient is still not bleeding. The patient was observed for a ten month period, a platelet count being made every two weeks. This count ranged from 11,000 to 70,000; yet only on three occasions did she exhibit petechial hemorrhages. During the bleeding phases there was no particular change in the platelet count. It would appear that in this case factors other than the platelet count were responsible for the bleeding episodes.

The next factor of considerable importance is the prolonged bleeding time in idiopathic thrombopenic purpura. Accurate technic is indispensable, as otherwise a false impression may be obtained. When

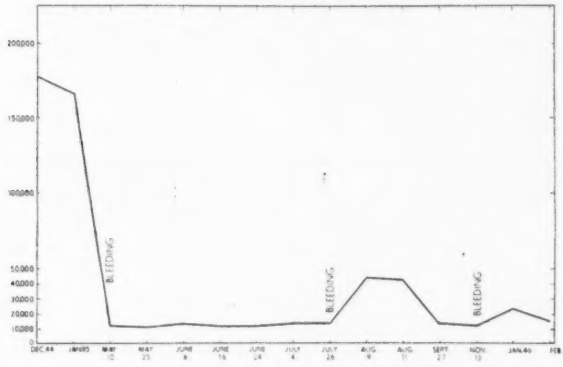

Fig. 1.—This chart indicates times of bleeding and platelet level per cubic millimeter of blood (case 10). Hemorrhage did not depend on a specific platelet level.

the puncture of the ear lobe is adequate, the bleeding time is usually found to be prolonged. Women patients often, but not invariably, bleed excessively during menstruation. Prolonged, and occasionally serious, nasal hemorrhage occurred in at least 2 of our patients when evidence of petechial hemorrhage was absent. Excessive menstrual bleeding and nasal hemorrhage associated with thrombopenia are in part clinical manifestations of prolonged bleeding time, which is the result of defective platelet thrombus formation.

As noted previously, a platelet thrombus is the first apparent response of the blood to vascular trauma. Ordinarily, there is a rapid deposition of platelets at the site of endothelial injury; very shortly this is followed by deposition of fibrin. Together, these two processes "plug up the leak," and hemorrhage is controlled. It is reasonable to assume that when the circulating platelets are diminished in num-

ber, as in thrombopenia, this repair process may be retarded to some extent, and a prolonged bleeding time may result.

Poor or entire absence of clot retraction is the third factor in thrombopenia. None of our patients had normal clot retraction when the platelet number was greatly reduced. The work of Tocantins [22] suggests that normal clot retraction may depend on the number of intact platelets which may persist in the thrombus after fibrin is formed: He found that extracts of platelets added to the blood of patients with thrombopenia did not correct impaired clot retraction, but that when intact platelets were added normal retraction did occur.

Elliott [23] stated that petechial hemorrhages in idiopathic thrombopenic purpura appeared to be more closely correlated with increased capillary fragility than with the actual platelet level. The diminished integrity of the capillary wall is particularly evident in ambulatory patients. In such cases gravity throws an added burden on the capillary wall, resulting in occurrence of petechiae chiefly in the lower extremities (fig. 2). The platelet counts were occasionally reduced to hemorrhagic levels without evidence of bleeding, and under these conditions the tourniquet (capillary resistance) test gave negative results. On the other hand, the hemorrrhagic aspect of the disease was always in remission when the platelet count returned to a normal level. In the absence of petechial or traumatic hemorrhage, our patients were clinically in good health regardless of the platelet levels.

It is not known just what defect in the capillary wall gives rise to petechial hemorrhage. While this defect has not gone without consideration, the platelet count has received greater attention. Clinically, at least, the capillary defect is probably more important than the platelet count. Unless the platelets are normally concerned in the maintenance of capillary integrity, it may be that the thrombopenia and the increased capillary permeability in this disease are distinct and different manifestations of a more fundamental, and as yet unknown, disturbance. Quick [24] suggested that a low grade overproduction of histamine in this disease might explain both the thrombopenia and the increased capillary fragility. Dale and Laidlaw [25] and Hanzlik

22. Tocantins, L. M.: Mechanism of Hemostasis, Ann. Surg. **125**:292 (March) 1947.

23. Elliott, R. H. E.: Suction Test for Capillary Resistance in Thrombocytopenic Purpura, J. A. M. A. **110**:1177 (April 9) 1938.

24. Quick A. J.: The Hemorrhagic Diseases and the Physiology of Hemostasis, Springfield, Ill., Charles C Thomas, Publisher, 1942.

25. Dale, H. H., and Laidlaw, P. P.: Histamine Shock, J. Physiol. **52**:355, 1918–1919.

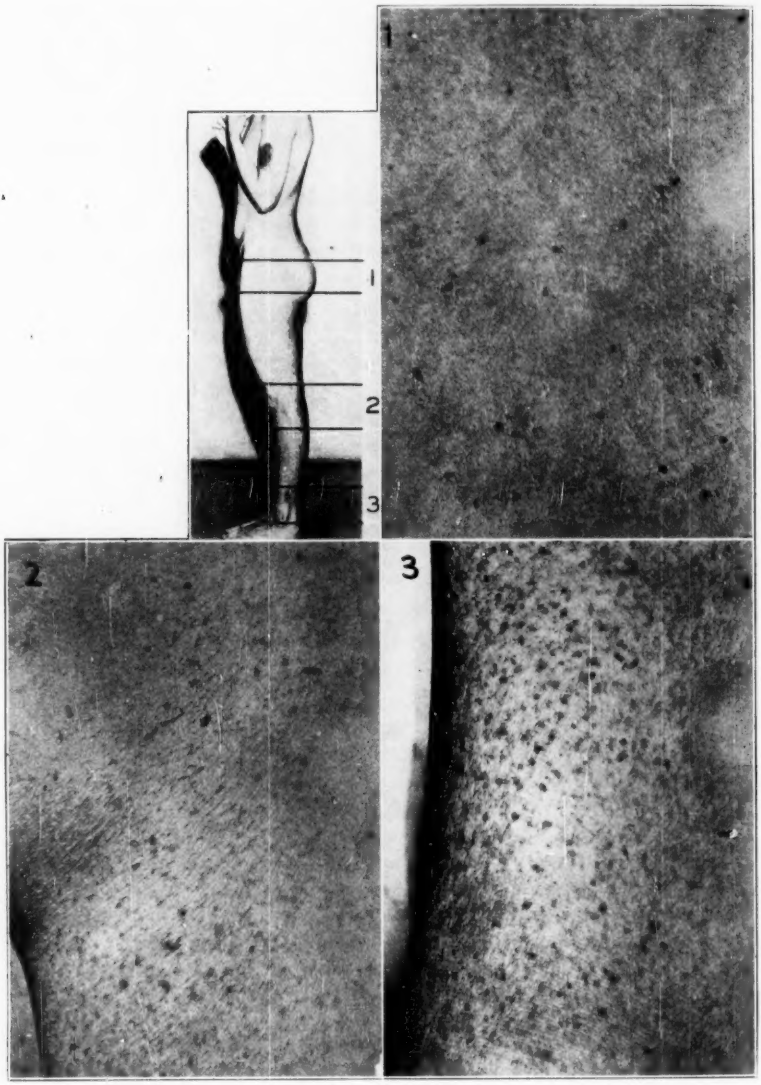

Fig. 2.—These photographs illustrate the increase in number of petechiae in the more dependent portions of the body (case 10). Enlargements *1*, *2* and *3* are from the portions indicated in the full body view.

and Karsner [26] have observed the clumping and trapping of platelets in capillaries, causing thrombopenia after injection of histamine. That histamine can increase capillary permeability is also well established. There is, however, no evidence that blood histamine is increased in idiopathic thrombopenic purpura, although it might be increased in amounts too small to detect by present day methods.

In general, two explanations for the thrombopenia have been suggested: (1) toxic suppression of megakaryocytic activity [27] and (2) increased destruction of platelets.[28] Both theories postulate some form of hypersplenism. If the spleen alone were involved, splenectomy should produce consistently good results. Unfortunately, this has not been the case. The failure of splenectomy to produce permanent results in all cases is even suggested by Kaznelson's original experience,[28] in which good results were obtained in only 1 of 3 splenectomized patients. Similar experience has been reported by many clinics, and, while reports differ in the degree of failures following splenectomy, it is evident that hypersplenism alone does not account for all the factors. Some workers [29] have attempted to explain failures on the basis of the regeneration of splenic tissue or of the hyperplasia of accessory spleens missed at the time of operation.

Capillary fragility in purpuric disease has been tested in a number of ways. The commonest methods employ either some form of negative pressure applied to a standard area of the skin or a means of increasing the intracapillary pressure by partial constriction of the venous blood return from the forearm. We have used the constriction method and have noted the presence or absence of petechial hemorrhage in the more dependent portions of the lower extremities of ambulatory patients as an additional guide to the state of capillary permeability.

Most writers have stated the belief that splenectomy is the treatment of choice in the severer cases of thrombopenic purpura. The results have been good, though they have not always been successful. The

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26. Hanzlik, P. J., and Karsner, H. T.: Further Observations on Anaphylactoid Phenomena from Various Agents Injected Intravenously, J. Pharmacol. & Exper. Therap. **23**:173, 1924–1925.

27. Torrioli, M., and Puddu, V.: Recent Studies on Pathogenesis of Werlhof's Disease, J. A. M. A. **111**:1455 (Oct. 15) 1938. Troland, C. E., and Lee, F. C.: Preliminary Report on Platelet-Reducing Substance in Spleen of Thrombocytopenic Purpura, Bull. Johns Hopkins Hosp. **62**:85 (Jan.) 1938.

28. Kaznelson, P.: Verschwinden der hämorrhagischen Diathese bei einem Falle von essentieller Thrombopenie (Frank) nach Milzexstirpation: Splenogene thrombolytische Purpura, Wien. klin. Wchnschr. **29**:1451, 1916.

29. Watson, C. J., and Moir, W. W., Jr.: Recurrence of Thrombocytopenic Purpura After Splenectomy in Case with Accessory Spleen, Internat. Clin. **4**: 221 (Dec.) 1941.

failures may have occurred in those cases in which the diagnosis was in error, though some failures have been reported by all workers. However, two factors remain to be explained: (1) Thrombopenia may return in a few weeks or months after splenectomy even when a careful search has been made for accessory splenic tissue, and (2) petechiae or spontaneous bleeding does not always accompany the reappearance of the thrombopenia. With regard to the first point, if the spleen were the only organ affected, its removal should produce a cure in all cases provided, of course, that the diagnosis of idiopathic thrombopenic purpura is correct. Such cures have not been the rule; the rates of recurrence have varied from 5 to 60 per cent.[30] With regard to the second point, one can state only that patients with

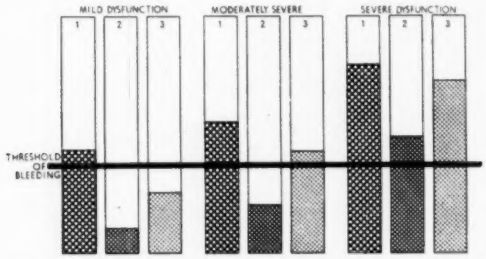

Fig. 3.—This chart indicates theoretic ratios between the degree of dysfunction of the reticuloendothelial system and the results of splenectomy. Splenectomy need not produce consistent results. Preoperative conditions, *1;* immediate postoperative results, *2;* long term postoperative results, *3.*

thrombopenia purpura may have remissions from bleeding without change in the platelet count.

A possible explanation, accounting for most of these discrepancies, is that the disease involves the entire reticuloendothelial system. This suggestion is not new.[20] It could explain how accessory splenic tissue may be responsible for failure following splenectomy, as well as why splenectomy is successful in most cases. Presumably, splenectomy in most cases removes enough of the reticuloendothelial tissue to produce a good result. Latent compensatory changes in the remainder of the reticuloendothelial system might in some cases be sufficient to permit its disturbed function again to produce thrombopenia and/or hemorrhages. Spontaneous fluctuations in the activity of this system could explain the variable course of the disease. Figure 3 is a diagrammatic sketch of this concept.

SUMMARY

Clinical data based on 20 cases of idiopathic thrombopenic purpura are presented. Ten of the patients in this group were treated medically, and 10 were subjected to splenectomy. Seven of the 10 patients treated medically were known to have had no recurrence for a period of six months to two years. Five of the 10 splenectomized patients had a recurrence; in 2 of these patients it was severe. Of the patients who had a recurrence, 3 had the acute disease and 2 the chronic disease.

Opinions concerned with the pathologic processes in thrombopenic purpura are discussed. The importance of the capillary abnormality, as well as the low platelet count, is emphasized. It is possible that the condition of the entire reticuloendothelial system, and not of the spleen alone, determines the course of the disease.

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30. Kaznelson.[28] Watson and Moir.[29]

MULTIPLE ARTERIAL EMBOLI

Three Successful Embolectomies in a Case of Bacterial Endocarditis

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AND
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IN THE thirty-six years since Labey [1] of France (1911) performed the first successful arterial embolectomy, widespread experience with this procedure has demonstrated its practical importance in prevention of gangrene and death from embolic obturation of systemic arteries. Prior to 1930 interest in this field was largely limited to the work in Scandinavian clinics, but in recent years many peripheral embolectomies have been performed in this country. Reviews of the surgical advances in treatment of arterial emboli have been made by Key [2] (1936), Haimovici [3] (1937), Linton [4] (1941), Pratt [5] (1942) and McClure and Harkins [6] (1943). These authors described the clinical and pathologic features of arterial embolism and emphasized the desirability of prompt embolectomy. Murray [7] (1940) stressed the advantage of giving heparin in conjunction with removal of the embolus.

Attempted embolectomies for repeated arterial emboli have been performed by a number of surgeons, but few successful cases have been reported. Deitch [8] (1936) removed an embolus from the left femoral artery with good result, and a year later in the same patient emboli were successfully removed from the right femoral and the left common

From the Departments of Surgery and Medicine of the Johns Hopkins University School of Medicine and the Johns Hopkins Hospital.

1. Labey, G., cited by McClure and Harkins.[6]

2. Key, E.: Embolectomy on the Vessels of the Extremities, Brit. J. Surg. **24**:350-361, 1936.

3. Haimovici, H.: Les embolies artérielles des membres, Paris, Masson & Cie, 1937, p. 336.

4. Linton, R. R.: Peripheral Arterial Embolism, New England J. Med. **224**:189-194, 1941.

5. Pratt, G. H.: Surgical Treatment of Peripheral Embolism, Am. J. Surg. **56**:566-572, 1942.

6. McClure, R. D., and Harkins, H. N.: Recent Advances in the Treatment of Peripheral Arterial Embolism, Surgery **14**:747-797, 1943.

7. Murray, G. D. W.: Heparin in Thrombosis and Embolism, Brit. J. Surg. **27**:567-598, 1940.

8. Deitch, H. I.: Three Arterial Embolectomies in the Same Patient Including One in Each Femoral Artery, Lancet **1**:475-477, 1936.

iliac artery. Groth[9] (1939) collected records of 6 cases of reembolectomy, in only 4 of which the operation had been successful in preventing loss of the extremity. MacFarlane[10] (1940) reported a case of multiple emboli with four successful embolectomies.

In the last few years the prognosis for patients with bacterial endocarditis has apparently been greatly improved by the use of penicillin.[11] The following case is illustrative of the value of prompt embolectomy in three successive episodes of arterial embolism occurring in a young man with this disease.

REPORT OF A CASE

History.—P. W., a 23 year old white man, a laborer, was admitted to the Osler Medical Clinic of the Johns Hopkins Hospital on Feb. 20, 1947, because of chills, fever, loss of weight and weakness. He had had attacks of rheumatic fever at 8, 12 and 15 years of age. One year before admission he had been confined to bed for three months with recurrence of rheumatic fever and had since been unable to return to work because of extreme exertional dyspnea. Seven weeks before entry he had noted the onset of fever and shaking chills, profuse night sweats and lassitude. A week later he had been operated on by his local physician for an anal fissure, and shortly after operation there had developed a spiking fever and migratory polyarthritis, relieved to some extent by salicylates.

Physical Examination on Admission.—His temperature was 101.6 F., his pulse rate 112, his respiratory rate 28 and his blood pressure 140 systolic and 40 diastolic. He was thin, apprehensive and dyspneic. His skin and mucous membranes were pale. Careful daily search revealed no petechiae. There was no general glandular enlargement. The teeth were in good repair, and the pharynx was normal. The lungs were clear. The heart was markedly enlarged in all its salients, the rate being rapid and regular, with a loud, coarse aortic diastolic murmur and a short presystolic rumble at the apex in the anterior axillary line. There were pronounced peripheral signs of aortic insufficiency. No palpable abdominal masses or viscera and no clubbing or edema of the extremities were present. There was evidence of a slight amount of fluid in the left knee joint the day after the patient's admission.

Laboratory Examinations.—The serologic test for syphilis gave a negative reaction; the hemoglobin measured 11.5 Gm. per hundred cubic centimeters; the red blood cell count was 3,650,000; the hematocrit reading, 35; the corrected sedimentation rate, 18 mm. per hour, and the white blood cell count, 11,000, with a normal differential count. The urine was normal. The electrocardiogram was within normal limits. Twelve blood cultures taken during the patient's first three days in the hospital were positive for Streptococcus viridans (mitior), the count being approximately 150 colonies per cubic centimeter. The nasopharyngeal culture

9. Groth, K. E.: Einige Fälle von rezedivierendes Arterienembolie in der Extremitäten, Arch. f. klin. Chir. **194**:413-457, 1939.

10. MacFarlane, J. A.: Multiple Emboli Treated Surgically, Brit. M. J. **1**: 971-972, 1940.

11. Keefer, C. S.: Chemotherapy in Management of Medical Infections, Chicago M. Soc. Bull **49**:500, 1947.

yielded no pathogenic organisms. At the time of the patient's admission the blood chemistry was as follows: nonprotein nitrogen, 31 mg., and sugar, 111 mg. per hundred cubic centimeters; chlorides, 103.2 milliequivalents; cholesterol, 88 mg. per hundred cubic centimeters; carbon dioxide, 21.2 milliequivalents; bilirubin, total 1.8 mg. per hundred cubic centimeters, with 0.8 mg. in the direct test; and serum protein, 5.1 Gm. per hundred cubic centimeters, with an albumin-globulin ratio of 2.9:2.2. The venous pressure was 95 mm. of water; the circulation time (arm to tongue), thirteen seconds ("dehydrocholic acid; decholin") and the vital capacity, 55 per cent of normal. Phenolsulfonphthalein excretion was 84 per cent in two hours. The cephalin flocculation test gave a negative result, and the reading in the thymol turbidity test was 6.2 units. Agglutination tests for brucellosis, tularemia, typhoid and paratyphoid gave negative reactions in all dilutions.

Course in Hospital.—On his admission it was felt that the patient had rheumatic heart disease with mitral stenosis and aortic insufficiency, acute rheumatic fever and, probably, bacterial endocarditis. While growth of the blood cultures was awaited, treatment with salicylates was started and the patient was digitalized. While the patient was receiving salicylates, the temperature descended to a lower range, and he felt a great deal better.

On February 24, after identification of the organism from the blood culture (Str. mitior) administration of penicillin was started, 100,000 units being given every two hours (1,200,000 units daily). Cultures of blood after treatment was begun remained sterile until that taken on March 4, which grew Str. mitior. On March 6 the dosage of penicillin was doubled (200,000 units every two hours). All subsequent cultures of blood were sterile. Sensitivity of the organism to penicillin was found to be 0.24 microgram per cubic centimeter and penicillin blood levels at intervals of fifteen, thirty, sixty, and one hundred and twenty minutes after injection of 200,000 units were found to be 5.0, 5.0, 3.7 and 3.7 units, respectively, per cubic centimeter.

There was one episode of acute pulmonary edema following gastric dilatation from surreptitious dietary indiscretion (6 oranges and 2 pints [1 liter] of ice cream on the afternoon of his birthday, March 4).

On March 13 at 4:30 p. m., while moving off the bedpan, the patient suddenly felt numbness, coldness and mild pain in the left foot. Examination showed pallor and coolness of the foot and absence of pulsations below the femoral artery on the left. In contrast, there were vigorous "water-hammer" pulses in the right foot and leg. The patient was immediately given papaverine hydrochloride (64 mg.) intravenously and morphine sulfate (16 mg.) subcutaneously. The surgical resident, who arrived within ten minutes, concurred in the diagnosis of embolism of the left femoral artery, and immediate embolectomy was decided on. Blood to be used in determination of prothrombin time was obtained and 300 mg. of dicumarol (3,3'-methylene-bis-[4-hydroxycoumarin]) was given orally before operation.

First Embolectomy (H. W. S. Jr.).—At 5 p. m., with the use of local anesthesia, the left femoral artery was exposed in Scarpa's triangle. The pulsations which had been felt in the artery before operation now proved to be of the transmitted type, and there was marked arteriospasm. A longitudinal incision 2 cm. in length was placed in the common femoral artery, which had been occluded with a bulldog clamp distally and a catheter proximally. There was no bleeding from the proximal segment. With a biliary stone forceps passed upward in the artery for 3 or 4 inches (7.5 or 10 cm.) above the inguinal ligament, a hard grayish white, bullet-shaped embolus 4 cm. in length was extracted, its removal being followed by a vigorous spurt from the proximal segment. A long, propagated thrombus was then

removed by suction from the distal segment and the arteriotomy opening closed with a continuous everting mattress suture of 00000 silk. After removal of the constricting devices, femoral pulsations were still feeble, and for this reason the arteriotomy wound was reopened and a second, smaller, embolus extracted with the stone forceps. Again there was vigorous bleeding proximally, and the arteriotomy incision was closed, after which procedure good pulsation returned to the foot.

After three or four minutes pulsation abruptly ceased in the exposed femoral artery; with considerable reluctance the surgeon opened the arteriotomy wound again and removed a third embolus in a manner similar to that described previously. After closure of the artery this time adequate return of circulation was maintained. The wound was then closed in layers with interrupted fine silk sutures. Lumbar sympathetic block was performed with a 2 per cent solution of procaine hydrochloride, and on the patient's return to the ward the foot had regained its warmth and color, with good pulsation in the popliteal, posterior tibial and dorsalis pedis arteries.

Postoperative anticoagulant therapy in the form of administration of heparin by continuous intravenous drip was given until the effect of the dicumarol was obtained. Administration of heparin was controlled by determination of clotting time every two hours. Clotting time was kept at fifteen to twenty minutes by giving 20 to 27 drops per minute of a 5 per cent solution of dextrose with added heparin, 600 mg. per liter. Pretreatment clotting time had been five minutes and prothrombin time twenty seconds. The use of heparin was discontinued after twenty-four hours, and dicumarol therapy was then maintained, the daily doses being calculated to keep the prothrombin time at 25 to 35 per cent of normal. The next five days were uneventful.

On March 8, at 5:30 p. m., while lying quietly in bed, the patient experienced a repetition of the signs and symptoms of embolus in the left femoral artery at the same level at which the other emboli had appeared. He received papaverine hydrochloride (64 mg.) intravenously at 5:40 p. m. and was immediately taken to the operating room.

Second Embolectomy (H. W. S. Jr.).—With the patient under spinal anesthesia, the healing wound in the left groin was reopened and the common femoral artery exposed. A hard embolus could be felt just above the site of the original arteriotomy. With the same technic as that used before, the embolus was removed through a new incision 3 cm. above the site of the previous arteriotomy. There was no significant narrowing and no evidence of thrombosis at the site of the old arteriotomy. After this procedure vigorous arterial pulsations returned, and there have been no subsequent circulatory disturbances in this limb.

Cultures were made of this embolus by first suspending it in broth and then triturating it with sterile emery, thus culturing the entire embolus. Both cultures remained sterile. Papaverine hydrochloride (320 mg. daily, injected intravenously) and dicumarol had been given since the first operation, and their administration was continued. Despite complete rest in bed and maintenance doses of digitoxin U. S. P. (0.2 mg. daily), the patient had several attacks of acute pulmonary edema, requiring morphine, oxygen and tourniquets. Circulation in the legs remained excellent, and there were no further embolic phenomena until March 25.

On March 25 at 7:45 p. m. a severe shaking chill occurred, followed by an elevation of temperature to 104 F. and another attack of acute pulmonary edema. At 8:10 p. m. the patient suddenly complained of pain in the right foot, which rapidly became cold, numb and pulseless. Pulsations were absent below the level of the popliteal artery. After the administration of morphine, papaverine and oxygen,

a lumbar paravertebral sympathetic block was performed. By 10 p. m. the patient's cardiac status was improved sufficiently to permit his transfer to the operating room with a preoperative diagnosis of embolism of the right popliteal artery.

Third Embolectomy (H. W. S. Jr.).—With the patient again under spinal anesthesia, the right popliteal artery was exposed through a transverse incision, and a hard embolus 4 cm. in length was removed from the artery at its bifurcation. There was then prompt and complete return of circulation to the extremity.

After this procedure the patient's condition remained surprisingly good, and the temperature fell from a peak of 106 F. to normal by morning. Because of another

P. W., three months after three successful arterial embolectomies for recurrent peripheral embolism of the left femoral and right popliteal arteries, occurring during bacterial endocarditis.

chill and elevation of temperature to 103 F. on the following day the penicillin dosage was increased to 400,000 units every two hours (4,800,000 daily). Cultures of blood during these elevations of temperature remained sterile. Prothrombin time was twenty-five seconds (50 per cent of normal) on March 27, and no further dicumarol was given. On April 2 all skin sutures had been removed and the wounds were healed nicely. The reassuring "water-hammer" pulses were present in both legs and feet, and there has been no further evident impairment of the peripheral circulation.

The next complication came in a different form. On the night of April 2 the patient was awakened by a sudden pain in the left upper abdominal quadrant, which required morphine for relief. The lungs were clear, and the heart beat was unchanged, but a friction rub and exquisite tenderness in the left portions of the flank led us to suspect a splenic infarct. By morning the pain had become sharply localized in the midabdomen and was accompanied with signs of generalized peritonitis. The white blood cell count had risen to 19,500, and roentgenograms of the chest suggested paralytic ileus, with no free air under the diaphragm. Because of the previous embolic episode, a diagnosis of mesenteric infarction appeared most likely, and it was felt that operation was indicated. Laparotomy revealed diffuse purulent peritonitis, but no source could be demonstrated. Careful examination of the abdominal viscera revealed no evidence of infarction, perforation or localized infection. Appendectomy was performed as a precautionary measure. Immediate smears of the odorless exudate revealed no organisms, and cultures on various mediums remained sterile.

After the operation the patient received streptomycin (0.3 Gm. every two hours) and sulfadiazine (1 Gm. every six hours) intravenously for twelve days, in addition to penicillin (400,000 units every two hours). No satisfactory explanation of the origin of the peritonitis was ever established. The patient's recovery from the peritonitis was slow and often uncertain, but surprisingly good for one who had as low a cardiac reserve as his and had already been subjected to so much. The course of convalescence was extremely stormy and was complicated by numerous episodes of pulmonary edema and signs of pulmonary infarction.

To date (July 1, 1947) he has had no subsequent phenomena of peripheral embolism. Use of penicillin was discontinued on April 20, after he had received a total of 324,000,000 units, and his blood cultures remain sterile. He is now ambulatory, but with restricted activities because of his cardiac status. The circulatory, motor and sensory status of his extremities has remained intact (figure).

COMMENT

A discussion of the incidence, pathogenesis and diagnosis of arterial embolism exceeds the scope of this report. As summarized recently by McClure and Harkins,[6] the optimal treatment of peripheral arterial emboli involving the lower extremities is prompt embolectomy, with local anesthesia, supplemented by lumbar sympathetic block and use of papaverine and anticoagulants.

The reported case illustrates the value of prompt recognition of the situation in repeated episodes of peripheral embolism and the desirability of close cooperation between medical and surgical services in utilizing this plan of treatment. Arterial embolism is a true surgical emergency, and a markedly diminished cardiac reserve should not be a deterrent to arterial embolectomy, with local or regional anesthesia.

Lumbar sympathetic block was not performed before the second embolectomy because a spinal anesthetic, accomplishing the same purpose, was given almost immediately. It is of interest to note that during the second and third embolectomies no excessive bleeding was encountered, despite the fact that the patient was fully dicumarolized. All wounds healed by first intention without hematoma or ecchymosis.

Major embolic phenomena occurring during the course of bacterial endocarditis are usually visceral.[12] Large peripheral emboli occluding the major vessels of the extremities apparently have been uncommon. Several observers[13] have noted an increased incidence of embolism since the advent of intensive penicillin therapy of this disease. It is possible that in the future, cases of the type reported here will be more frequently encountered.

Johns Hopkins Hospital (5).

12. Libman, E., and Friedberg, C. K.: Subacute Bacterial Endocarditis, in Christian, H. A.: Oxford Medicine, New York, Oxford University Press, 1947, vol. 2, pt. 2, chap. 10a.

13. King, J. T.: Personal communication to the authors.

LIGATION OF CAROTID ARTERIES FOR ADVANCED MALIGNANT NEOPLASMS OF THE HEAD AND NECK

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THE management of patients with advanced malignant neoplasms often necessitates an emergency surgical procedure. In the treatment of eroding neoplasms of the head and neck, ligation of the major arteries supplying these anatomic areas may become a necessity for the preservation of life. In these circumstances it may be indicated to ligate the common carotid artery or the external carotid artery, and sometimes certain of its branches.

Ligation of these vessels is advocated (1) to protect against bleeding, as a preliminary step to a radical surgical procedure on the head or neck; (2) to control active hemorrhage, and (3) to diminish the blood supply to inoperable neoplastic lesions, in the hope of decreasing the tumor growth and/or of preventing bleeding.

Specifically, the common carotid artery may be ligated to control profuse hemorrhage from the deeper structures of the upper cervical regions, as well as from ulcerating neoplasms in the throat. This artery has also been ligated in order to interrupt the circulation through an aneurysm. Usually the external carotid artery is ligated as a preparatory procedure in extensive operations on the face and neck. This is a precautionary measure prior to the resection of carcinoma of the upper jaw or excision of malignant lesions from the pharyngeal wall. Ligation of the internal carotid artery is rarely performed in the surgical management of carcinoma of the head and neck. This artery was not ligated in any of the cases presented in the current series.

PREOPERATIVE CONSIDERATIONS

Prior to ligation of any of the carotid arteries the most important preoperative consideration is the carotid sinus syndrome. The role of the carotid sinus has been proved to be a reflex-controlling mechanism

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of the endovascular blood pressure. The dilated portion at the bifurcation of the common carotid artery is the site of origin of this reflex, through innervation of the adventitia of the vessel.

Ligation of the carotid artery may produce a carotid sinus syndrome which results in episodes of unconsciousness and/or convulsions. These attacks may result in cerebral depression of the blood pressure.

In order to avoid this complication when surgical ligation of the carotid artery is contemplated, the following preoperative measure is recommended. The artery on the side of future operations should be compressed each day for a gradually increasing period up to ten minutes. This means that the carotid artery on the side of operation can be compressed for a total of ten minutes without any undue symptoms. It is, of course, appreciated that in the presence of an emergency to save life in case of hemorrhage this procedure cannot be followed. In these circumstances, and in sensitive persons, injection of 0.5 per cent procaine hydrochloride may be made into the carotid bulb. The solution is injected at the bifurcation of the carotid artery, where the sensory receptive fibers originate. Here the nerve leaves the sinus as the intercarotid nerve (nerve of de Castro) to join the glossopharyngeal nerve. Through this pathway the afferent nerve connection between the carotid sinus and the medullary center [1] exists. Injection of procaine hydrochloride blocks this nerve reflex and abolishes the possibility of the carotid sinus syndrome.

OPERATIVE APPROACH TO THE CAROTID ARTERY

The surgical approach to the carotid arteries is by means of an incision along the anterior margin of the sternocleidomastoid muscle. The center of the 8 cm. incision is at the level of the cricoid cartilage. Retraction of the sternocleidomastoid muscle posteriorly brings into view the omohyoid muscle inferiorly. This muscle may be divided if necessary. The descending hypoglossal nerve is retracted laterally. For more adequate exposure the thyroid gland may be drawn medially if necessary. This enables the common carotid artery to be more easily identified. Silk ligatures may then be placed about the artery with ease. In the course of this procedure care must be taken not to include the vagus nerve.

The same approach is employed for the external carotid artery. The site of selection for ligating this vessel is between the superior thyroid and the lingual artery. On occasion we have ligated both the carotid artery and the lingual artery. The landmark in choosing the site of ligation of the external carotid artery is at the level of the greater horn

1. Carotid Sinus Syndrome, editorial, J. A. M. A. **132**:24 (Sept. 7) 1946.

of the hyoid bone. In ligating the external carotid artery, the superior laryngeal nerve must be avoided. This structure lies behind the artery.

The cervical portion of the internal carotid artery is identified through the same procedure as that used for exposing the external carotid artery. In our own experience, we have never had occasion to ligate the internal carotid artery alone. In the cases presented the arteries were ligated with black silk. We have done ligations on these

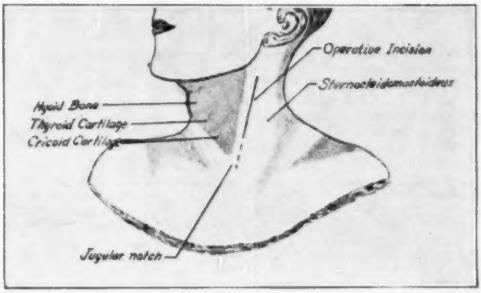

Fig. 1.—Operative approach to the carotid arteries. The hyoid bone is a landmark for ligating the external carotid artery.

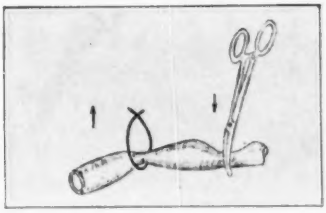

Fig. 2.—Method of gradual arterial compression by pulling upward on the ligature and pressing downward with a clamp.

vessels gradually in order to avoid sudden fall in cerebral circulation. This method of gradual occlusion of the vessel is also prophylaxis against the stimulation of the carotid sinus. By this means of occlusion, the silk ligature is drawn upward and the artery pushed downward with a clamp. The method enables release of the artery in the event that unusual symptoms referable to the carotid sinus develop. A sudden rise in the pulse rate may occur at the time of ligating the vessel. With this particular procedure the arterial circulation can be returned immediately by removing the closed clamp and lowering the black suture.

Data on 26 Cases with Advanced Malignant Neoplasms of Head and Neck in Which Carotid Arteries Were Ligated

Case No.	Age, Yr.	Sex	Pathologic Condition	Arteries Ligated	Eventual Outcome
1	62	M	Carcinoma of buccal mucosa	Left external carotid proximal to superior thyroid	Patient had complete right hemiplegia with aphasia 9 days after operation; died 3 years later in psychiatric institution
2	47	M	Squamous cell carcinoma of extrinsic part of larynx	Left external carotid	Thirty-three days after operation patient bled for 2 days from operative site, in spite of pressure; died of exsanguination
3	52	M	Squamous cell carcinoma of hypopharynx	Fifty per cent contraction of left common carotid; bifurcation in tumor tissue	Patient had tie on left common carotid artery tightened 2 days after operation; 4 days after operation had symptoms referable to left eye, with funduscopic hemorrhage and loss of color vision; course rapidly downhill; patient died 11 days after operation
4	54	M	Squamous cell carcinoma of right side of lower lip	Right common carotid	Patient complained of headache, weakness and inability to swallow; died 11 days after operation
5	50	M	Squamous cell carcinoma of tonsil	Right common carotid	Patient recovered from operation but complained of pain in right ear, which could not be controlled except by sedation; died 30 days later
6	33	M	Adamantinoma of right side of mandible and maxilla	Right common carotid	Patient continued to have hemorrhage and died 7 days after operation
7	52	F	Carcinoma of tongue	Left common carotid	Pulsation noted in right temporal artery 2 days after operation; patient died at home 24 days after operation
8	60	M	Carcinoma of buccal mucosa on left side	Left external carotid	Patient survived operation; died at home 6 months later
9	72	M	Carcinoma of lower alveolar ridge	Right external carotid	Patient survived operation; followed in outpatient department; died at home 27 months later
10	58	M	Carcinoma of tongue	Left external carotid	Patient was transferred to Welfare Island 4 months after operation; no note on outcome
11	52	M	Fibrosarcoma on left side of neck	Left common carotid	Patient went into complete vascular collapse 8 days after operation, and died; no autopsy
12	77	F	Recurrent giant cell tumor of right side of mandible; fibrosarcomatous changes	Right external carotid	Patient died 1 hour after operation
13	62	M	Epithelioma of floor of mouth	Right common carotid	Patient survived operation; had resection of right side of mandible, followed by therapy and insertion of radon seeds; now living and well, without recurrence, 1 year after operation
14	58	M	Carcinoma of floor of mouth	Right lingual and right common carotid	Patient died 3 months after operation
15	50	M	Carcinoma of floor of mouth	Left common carotid	Wounds sloughed badly; patient died 9 days after operation
16	50	M	Carcinoma of left alveolar ridge	Left external carotid	Patient's wound broke down; several severe hemorrhages occurred; course downhill; patient died 3½ months after operation
17	67	M	Carcinoma of floor of mouth	Right external carotid and right lingual	Patient recovered from operation; 4 weeks later had resection of right side of mandible; died of pneumonia 8 days later
18	64	M	Carcinoma of of mouth and tongue	Left external carotid and left lingual	Patient continued to bleed; after 2 days went to operating room for ligation of opposite lingual artery; died on operating table; cause unknown

Data on 26 Cases with Advanced Malignant Neoplasms of Head and Neck in Which Carotid Arteries Were Ligated—Continued

Case No.	Age, Yr.	Sex	Pathologic Condition	Arteries Ligated	Eventual Outcome
19	59	M	Carcinoma of left alveolar ridge	Left external carotid	Twelve days after operation patient had spontaneous pneumothorax, which responded to supportive treatment; patient transferred to nursing home 42 days, and died 106 days, after operation
20	51	M	Carcinoma of right side of tongue	Right external carotid	Patient recovered, was discharged, seen in outpatient department, readmitted in poorer state and transferred to Welfare Island; died 231 days after operation
21	40	M	Epidermoid carcinoma of lower lip	Right common carotid	Patient recovered from operation, was transferred to House of Calvary and died approximately 90 days after operation
22	60	M	Carcinoma of left tonsil	Left external and left common carotid	Pneumonia developed 24 hours after operation, controlled; patient discharged and died 216 days after operation
23	63	M	Carcinoma of right angle of mouth	Right common carotid	Patient grew progressively worse; died 64 days after operation
24	48	M	Carcinoma of right angle of mouth	Right common carotid	Patient died 90 days after operation at House of Calvary
25	69	M	Carcinoma of floor of mouth	Left lingual and left external carotid	Patient went to operating room for resection of left side of mandible 25 days after operation and died on 113th postoperative day
26	67	M	Carcinoma of tongue	Left lingual and left external carotid	Elevation of temperature, 2 days after operation, thought due to focal atelectasis and pneumonitis; patient died 6 days after operation

COMMENT

Our experience in ligating the carotid arteries for advanced malignant growths of the head and neck consists in 26 cases seen at the Brooklyn Cancer Institute. In this series the youngest patient was 33 years of age and the oldest 77. Twenty-four patients were men and 2 were women. All of them had advanced neoplasms. The majority were not satisfactory operative risks. The underlying pathologic conditions and their distribution were as follows:

Pathologic Conditions	Number of Cases
Carcinoma of the floor of the mouth	6
Carcinoma of the tongue	4
Carcinoma of the alveolar ridge	3
Carcinoma of the buccal mucosa	2
Carcinoma of the lip	2
Carcinoma of the tonsil	2
Carcinoma of the angle of the mouth	2
Carcinoma of the external portion of the larynx	1
Carcinoma of the hypopharynx	1
Fibrosarcoma of the neck	1
Giant cell tumor of the mandible	1
Adamantinoma of the mandible and maxilla	1

The operative procedure was performed on either the right or the left side, according to the location of the lesion. On one occasion

the left external carotid artery was ligated to control hemorrhage; but this proved ineffectual, and the left common carotid artery had to be ligated (case 22).

All the patients in this series had advanced lesions, as shown in the tabulation. With this primary pathologic condition, they were not considered the best type of operative risks. The expected mortality, therefore, would be high, not because of the procedure alone but in view of the fact that the patients were debilitated by long-standing neoplastic lesions. In our series the mortality was not unusually high. One patient died on the operating table. Another succumbed one hour after the operation. A third patient died on the second postoperative day, while another died on the seventh postoperative day. A fifth patient succumbed on the ninth postoperative day. The remaining 21 patients survived the immediate postoperative period and lived for several weeks to several years. The longest period of survival was three years. Another patient lived for twenty-seven months, and the third has been followed for one year and is living and well at the time of writing.

In view of the eventual outcome in this series of 26 patients, it is our belief that ligation of the carotid arteries in the presence of an advanced malignant growth is not a procedure associated with an exceptionally high mortality. It may be considered a valuable adjunct to the armamentarium of the cancer surgeon. There can be little doubt that for many of the patients subjected to this procedure the operation was life saving. With other patients radical surgical intervention would have been impossible without the preliminary step of ligating the major vessels of the neck.

SUMMARY AND CONCLUSIONS

A report is presented of 26 cases in which ligation of the carotid arteries was performed for advanced malignant neoplasm of the head and neck.

This procedure is advocated mainly to control hemorrhage and as a preliminary step to radical surgical procedures on the head and neck.

The importance of the carotid sinus syndrome in this procedure is mentioned.

The operative approach to the carotid arteries is discussed.

The survival of 21 patients in a series of 26 indicates that this procedure is not associated with a formidable mortality.

The youngest patient operated on was 33 years of age and the oldest was 77.

The procedure was performed on 24 men and 2 women.

The cases presented here are categorized according to the type of lesion present and the arteries ligated.

Follow-up studies on these patients to date indicate that the longest survival after operation is three years.

Ligation of the carotid arteries is advocated as a valuable asset in the management of patients with advanced malignant neoplasms of the head and neck.

Dr. Howard T. Craven compiled the data on the cases presented in this report.

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USE OF BARREL STAVE GRAFTS IN SPINAL FUSION

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HENRY and Geist[1] in 1933 reported a modified Hibbs type of spinal fusion in which multiple chip grafts from the tibia were used. This modification simplified the spinal fusion operation by assuring an adequate supply of bone which would conform to any curvature or angulation of the spine, at the same time causing less shock than attends a more extensive surgical procedure. In the procedure which they described, no attempt was made to remove the articular facets. This type of spinal fusion has now been used over a period of many years and has proved most satisfactory for both children and adults. One difficulty, however, has been encountered in obtaining the grafts and insuring that the desired amount of bone will be procured. In young children multiple chip grafts can be removed from the tibia smoothly and easily with a sharp gouge, since the bone is less sclerotic than that of older persons. In children 14 years of age and older and in adults, however, the bone of the tibia is usually denser, and the chip grafts are difficult to obtain. In some instances the attempt to do this is comparable to removing small chips from the surface of a piece of marble. This situation has resulted at times in loss of some of the bone chips, and on occasion in an insufficient amount of bone to cover adequately the area to be fused.

In an attempt to obviate the difficulty which was encountered in obtaining the multiple chip grafts, we have used recently the barrel stave grafts as described by Steele.[2] The barrel stave grafts are simply long strips of full thickness tibial cortex cut approximately ⅛ inch (3 mm.) in width with a motor saw. These grafts may be placed either on edge or on the flat surface, and they are usually flexible enough to

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1. Henry, M. O., and Geist, E. S.: Spinal Fusion by Simplified Technique, J. Bone & Joint Surg. **15**:622-625 (July) 1933.

2. Steele, P. B.: Treatment of Nonunion; Barrel-Stave Grafts, in Reconstruction Surgery, Lectures in the Instructional Courses, American Academy of Orthopaedic Surgeons, January 1944, Ann Arbor, Mich., Edwards Bros., 1944, p. 22.

be made to conform to any deformity or curve of the spine. If multiple chip grafts are desired, the long barrel stave grafts can be cut into small chips by means of a bone rongeur. Except for the alteration in the type of graft used, this technic for spinal fusion is carried out in exactly the same way as that described by Henry and Geist.[1] The procedure has been used repeatedly for fusion in cases of

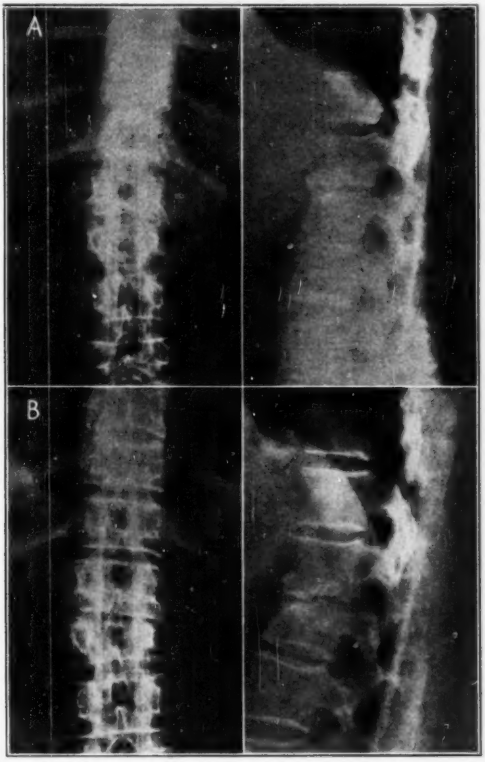

Fig. 1. (F. C., aged 38).—*A*, tuberculosis of the spine three months after arthrodesis by means of barrel stave grafts reenforced with multiple chips of iliac bone. Three long barrel stave grafts were used on each side, as can be seen in the roentgenogram at the left. *B*, one year after the operation. The barrel stave grafts can still be outlined, but increased new bone formation is visible in the lateral view.

tuberculosis of the spine (fig. 1), scoliosis (fig. 2) and spondylolisthesis (fig. 3), and occasionally for fixation of other lesions, such as hemangioma of the vertebra (fig. 4). In the present series of 25 cases,

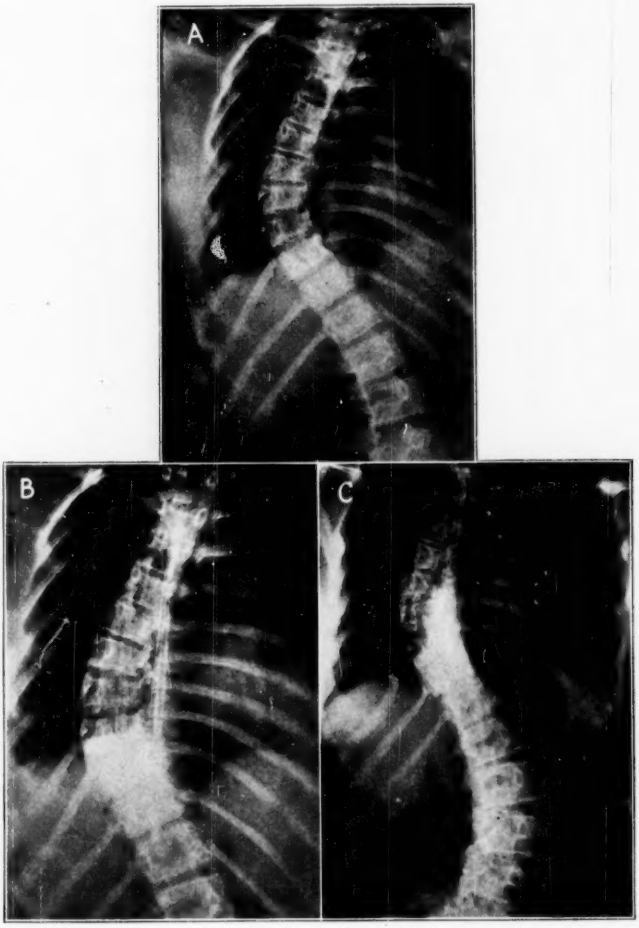

Fig. 2 (V. L., aged 15).—*A*, idiopathic scoliosis prior to institution of treatment. *B*, the same spine nine weeks after the first stage of spinal fusion. Fixation and this degree of correction were obtained by means of a traction brace (Blount). Note that the barrel stave grafts on the concave surface completely bridge the concavity of the curve. *C*, appearance eleven months after the first stage, and nine months after the second stage, of spinal fusion. The barrel stave grafts have now lost their identity. Note the heavy deposits of bone on the concavity of each curve.

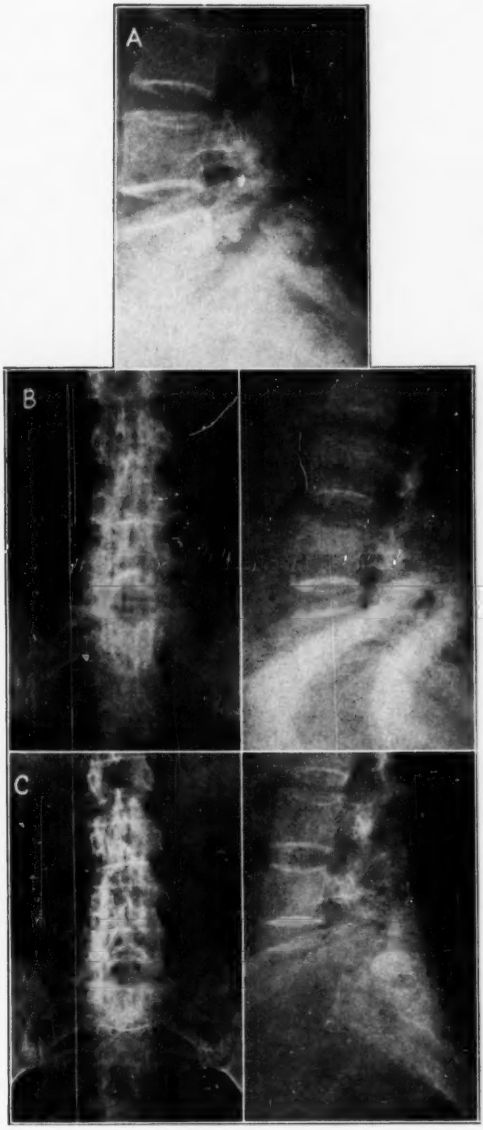

Fig. 3 (D. T., aged 43).—*A*, spondylolisthesis with pseudarthrosis following two previous spinal fusions, in which multiple chip grafts from the tibia had been used. *B*, six months after a third spinal fusion, in which barrel stave grafts reenforced with chips of cancellous iliac bone were used. Note the massive bone graft now spanning the defect. In the anteroposterior view the multiple barrel stave grafts are still visible. *C*, twenty months after the arthrodesis. Complete bony fusion is apparent. The identity of the barrel stave grafts is now being lost.

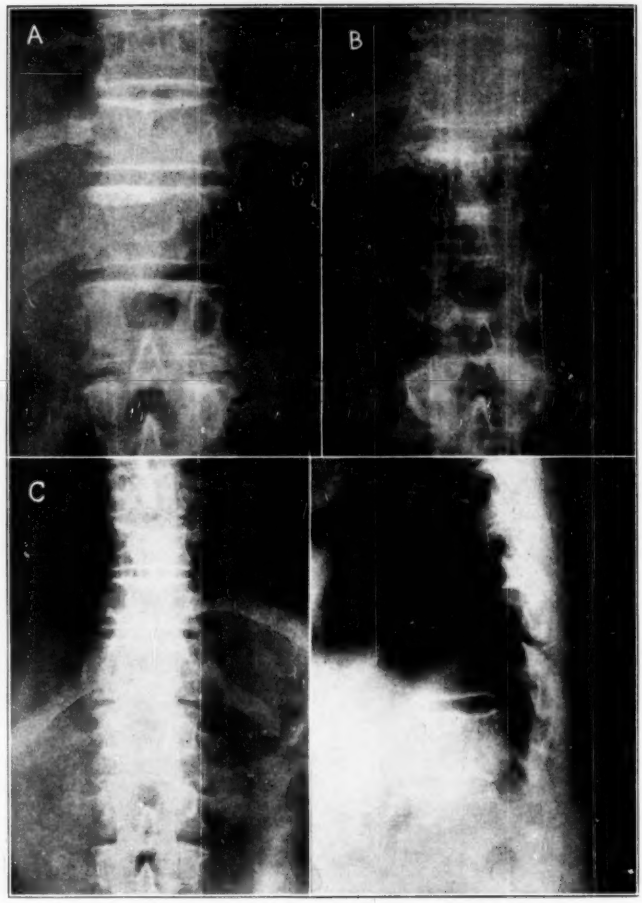

Fig. 4 (R. M., aged 58).—*A*, hemangioma of the twelfth thoracic vertebra. *B*, immediately after spinal fusion, in which barrel stave grafts reenforced with multiple chips of iliac bone were used. Six barrel stave grafts were used, and the three grafts can be identified on each side. *C*, one year later, when fusion seems satisfactory and the barrel stave grafts are losing their identity. In the lateral view, note the heavy mass of bone along the spinous processes.

excellent arthrodesis has been obtained in all except that of a child with spondylolisthesis which was associated with severe congenital osteochondritis. In this case a pseudarthrosis necessitated a second operation.

In many instances the barrel stave grafts have been reenforced with multiple chip grafts of cancellous bone removed from the posterior portion of the iliac crest. With a combination of this type, a more satisfactory spinal fusion can as a rule be expected than with either cortical or cancellous bone alone. It is possible that the incidence of pseudarthrosis and of postoperative fracture of the graft can be appreciably diminished by the use of a combined procedure of this type.

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HISTOLOGIC AND CHEMICAL ASPECTS OF THROMBUS FORMATION

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REGARDLESS of the methods preferred in the treatment of venous thrombosis, the physiologic events in the process of thrombus formation must guide the physician in his therapeutic considerations. What is called a vascular thrombus today was considered an outgrowth of the vascular wall by anatomists until the middle of the past century. Rudolf Virchow [1] was the first one to recognize these "outgrowths" as blood clots. He also described the mechanism of embolism, and his concept of thromboembolic disease is fundamentally as dominant now as it was one hundred years ago. Among the many papers which have appeared since Virchow's classic work, a few can be listed as contributing substantially to a better understanding of thromboembolic disease. Glénard [2] and von Baumgarten [3] showed independently that blood does not clot, even if kept stagnant for days between ligatures applied to a vein, as long as the vascular lining remains intact. The Viennese biochemist Freund [4] was able to demonstrate that even extravasated blood does not clot if collected under a paraffin film in a paraffin-lined container. However, the least defect in the water-repelling paraffin lining and film creates a condition favorable to clotting. Freund showed that the innermost vascular lining is water repelling, like paraffin. Any lesion of this lipid-like lining is a potentially germinative center of thrombus formation. Such lesions are frequently produced by processes closely related to allergy. As was pointed out by Dietrich,[5] small aggregations of cells may arise in the venous endothelium as the effect of toxic substances produced by focal infections. These cellular aggre-

1. Virchow, R.: Gesammelte Abhandlungen zur wissenschaftlichen Medicin, Frankf. a. M., Meidinger Sohn u. Comp., 1856.

2. Glénard, F.: Contribution à l'étude des causes de la coagulation spontanée du sang à son issue de l'organisme, Paris, Ve. A. Delahaye, 1875.

3. von Baumgarten, P. C.: Die sogenannte Organisation des Thrombus, Virchows Arch. f. path. Anat. **76**:268, 1877.

4. Freund, E.: Ein Beitrag zur Kenntniss der Blutgerinnung, Med. Jahrb. **1**:46, 1886.

5. Dietrich, A.: Gefässwand und Thrombose, Verhandl. d. deutsch. Gesellsch. f. Kreislaufforsch., 1934, p. 48.

gations break up the lipid-like lining and roughen its surface. The identity and origin of the invading cells have not been determined yet. No micro-organisms have ever been found in these microscopic "Dietrich nodules" or in their vicinity. With advancing age the patient passes through a number of more or less serious focal infections and allergies, and the venous system acquires an increasing number of irregularities in its lining, although this condition may not cause any circulatory embarrassment for a long time.

Children up to the age of puberty normally possess efficient circulatory power, and the blood of the young easily passes over these minute entanglements. A man may accumulate toxic nodules throughout his life without the formation of a thrombus as long as the circulatory conditions remain favorable. If, however, some circulatory disturbance arises, then the blood secures a hold on a nodulous spot, and the formation of a thrombus commences.

Virchow considered a thrombus to be a blood clot identical in composition and structure to an extravascular clot. In about 1875, Zahn[6] produced proof of the existence of an active, selective cellular process that initiates thrombus formation. In a series of ingenious and well planned experiments, he demonstrated the fact that a thrombus always starts with the accumulation of white blood elements, regardless of whether the causative irritant is mechanical or chemical. After placing a small crystal of sodium chloride on a frog's mesentery, he could see, within a short time, that all the blood vessels around the spot had become packed with white blood cells, the veins being obviously more involved than the arteries. When warm-blooded animals, such as rabbits, were subjected to this treatment, they showed similar reactions so far as the experiment was performed on an area of small veins.

Zahn then carried his experiments to the intravenous injection of a saturated solution of sodium chloride. He noted that first accumulations of white blood elements appeared at the site of the injections and settled around the injured places, often occluding the lumens of the vessels. Later, on the foundation provided by this white plug, blood coagulated and formed a common clot. Thus a thrombus was seen to consist of two principal parts: a white head, adhering firmly to the vascular wall, and a red tail, fixed by one end to the head, with most of its substances floating in the vessel. An intermediate portion, which contained more white cells than there are in a common clot, was usually interpolated between head and tail. In small veins the mass of the white head greatly exceeds that of the red tail. However, this proportion is reversed in larger veins, such as those of the caliber of the human saphenous or femoral vein, where the red tail forms almost the entire

6. Zahn, F. W.: Untersuchungen über Thrombose: Bildung der Thromben, Virchows Arch. f. path. Anat. **62**:81, 1875.

body of the thrombus. In some cases a lesion of the endothelium is followed only by a leukocyte and platelet reaction, which does not give rise to the production of a red clot. Instead, there results a more or less uniform investment of white blood elements. The factors on which this formation depends are the caliber of the vessel, the size and kind of the lesion and the state of the local circulation.

I believe that the two stages of thrombosis as described by Zahn differ fundamentally in their biologic significance. The white plug represents a process of repair and healing related to the formation of scar tissue, while the red tail constitutes a pathologic reaction. With circulation of the blood unabated, as it usually is in children, a red tail does not form on the white plug. However, when the circulation slackens locally or generally, a red tail may come into existence at any time. The formation of both the white plug and the red tail seems to be preceded by a biochemical process, preparing a sticky medium. Dietrich [5] described a delicate precipitate which first covers the injured lining. This precipitate shows no definite microscopic structure and does not take on Weigert's stain for fibrin. Consequently, I find it hard to accept Dietrich's conclusion that the mentioned precipitate is a true fibrinous substance. However, by a peculiar interaction of glucose, fibrinogen can be converted into a sticky gel phase without assuming qualities of fibrin.

As was pointed out by the Netherland authors Brinkman and van Dam [7] and van Creveld and Brinkman,[8] any irritation can produce pronounced changes in the surface of the corpuscular blood elements. According to the aformentioned workers, glucose is found only in the plasma, not in the corpuscular elements, if human blood is carefully collected under a paraffin film in paraffin-lined containers. At the least disturbance, however, glucose accumulates on the corpuscular surfaces. There it stays for hours, and even days, and it penetrates the corpuscular bodies only very gradually. The rate of penetration can be measured by the increase in size of the corpuscles. In experiments carried out at the Institute of Colloidal Chemistry at Vienna, Friedlander [9] found that glucose, in a concentration twice or more that of the isotonic solution, converts the normal sol of fibrinogen into its gel phase, not allowing it to assume fibrinous qualities; i. e., the

7. Brinkman and van Dam: Remarques sur la question de la répartition de la dextrose entre les globules rouges et le plasma, Arch. internat. de physiol. **15**:105, 1919.

8. van Creveld, S., and Brinkman, R.: Ein direkter Beweis für die Impermeabilität der Blutkörperchen des Menschen und des Kaninchens für Glukose, Biochem. Ztschr. **119**:65, 1921.

9. Friedlander, E.: Kolloidchemische Vorgänge bei der künstlichen und spontanen Thrombose, Wien. klin. Wchnschr. **42**:1451, 1937.

fibrinogen clot does not take on Weigert's fibrin stain, and it does not retract.

If glucose concentrates at a small area of irritation on a blood corpuscle, it can easily produce a flake of fibrinogen gel, thus causing a local stickiness of the surface. As a matter of fact, Wöhlisch and Bohnen [10] saw filaments of fibrinogen extending from one erythrocyte to another. Tannenberg and Fischer-Wasels [11] have given an almost dramatic account of the effect of increasing stickiness acquired by white blood elements passing an area of irritation in a vessel. The fact that red tail formation has a much higher incidence in man than in animals is probably due, at least in part, to the difference in the relation of glucose to the erythrocytes in man and in animals as far as tested. According to the Netherland workers mentioned, glucose did not accumulate on the erythrocytes of their experimental animals.

To a certain extent the organism possesses regulative processes which counteract the conglutination of erythrocytes. As has been pointed out by the Finnish physiologist Hammarsten,[12] a sufficiently high concentration of an electrolyte, especially sodium chloride, prevents clot formation. This action holds true with regard to the formation of a fibrinogen gel as well as to that of fibrin. Under conditions of circulatory congestion the migration of chloride from the plasma into the cellular bodies is facilitated by an increased carbon dioxide tension, which is usually associated with venous congestion, and the negative charge of the chlorine ions helps to neutralize the positive charge of the fibrinogen. This observation may in part explain why a salt-free diet favors thrombus formation in diabetic patients, as Lapp and Dibold [13] reported.

At present, therapeutic considerations are generally guided by the classification of thrombus formation into phlebothrombosis and thrombophlebitis, as proposed by Ochsner and his co-workers.[14] These authors stated the belief that thrombophlebitis is due to a primary inflammatory process involving the wall of the vein and that the thrombus is secondary to the inflammatory process. They claimed that, because of the inflammatory process, the thrombus which is formed is a white thrombus and is firmly attached. There may occur a red, or coagulation,

10. Wöhlisch, E., and Bohnen, P.: Mikroskopische Untersuchungen am Schwangerenblut, Klin. Wchnschr. **3**:472, 1924.

11. Tannenberg and Fischer-Wasels: Die lokalen Kreislaufstörungen, in Bethe, A., and others: Handbuch der normalen und pathologischen Physiologie, Berlin, Julius Springer, 1928, vol. 7, pt. 2, p. 1669.

12. Hammarsten, O.: A Textbook of Physiological Chemistry, Wiesbaden, J. F. Bergmann, 1893, p. 55.

13. Lapp, F. W., and Dibold, H.: Thrombose und Embolie bei salzloser Kost, Deutsche med. Wchnschr. **62**:1206, 1936.

14. Ochsner, A., and DeBakey, M.: Therapy of Phlebothrombosis and Thrombophlebitis, Arch. Surg. **40**:208 (Feb.) 1940.

thrombus, as a tail to this. This process, however, is similar to the process of phlebothrombosis. In phlebothrombosis, it is possible for the thrombus to become attached to the venous wall and ultimately lead, according to Ochsner,[15] to thrombophlebitis.

To date, it has been a general belief, shared by the majority of authors of textbooks on pathology, that a stratum of white thrombus substance spreads over a comparatively wide area of venous lining preceding the coagulation of blood on the basis of this stratum. However, in studying histologic sections of varicose and other thrombi, I was puzzled by the rare occurrence of what could pass for a stratum of white thrombus substance. Areas of that sort were usually microscopically small. Later I found out that my observation was not new at all. On a material, larger and better selected than mine, Zahn [6] had shown in 1875 that white plugs contribute the bulk of a thrombus only in small vessels, while their size diminishes rapidly with the increase of the vascular caliber. He found that in veins the size of the human femoral vein white plugs are usually so small that they often escape attention. Probably this fact was the reason that the process of white thrombus formation escaped entirely even Virchow's keen eyes. In larger veins the bulk of a thrombus is made up of the red tail, while the original white plug is very small. The histologic pictures of transections of mixed and white thrombi, seen in most of the American and European textbooks, are doubtless correct, but the texts say nothing about the incidence of the different formations.

I feel that practically every thrombus tail in a large vein starts as a floating body. It depends on the therapeutic management whether this body remains floating or gets attached along the venous wall. The secondary attachment of a thrombus tail occurs by a process different from that of white thrombus formation. When contacting the vascular wall, the thrombus is arrested in situ by the fibrin on its surface. Only much later can cellular immigration be seen, and the process of organization starts after a period of weeks. However, the first phase of attachment by fibrin seems to be sufficient as a protection against embolism. So far, not one case of pulmonary embolism has ever been found in which the embolus showed vestiges of previous attachment. By proper management the majority of floating thrombi can be brought to an attachment to the venous wall, thus fixing them to their original site, as shown in the treatment of thrombosis of the lower portion of the leg by Fischer [16] and of femoral and pelvic thrombosis by Friedlander.[17]

15. Ochsner, A.: Personal communication to the author.

16. Fischer, H.: Eine neue Therapie der Phlebitis, Med. Klin. **30**:1172, 1910; Zur Therapie der Stauungen der unteren Extremitäten und ihrer Folgen, München. med. Wchnschr. **4**:116, 1923.

17. Friedlander, E.: Anatomische Grundlagen zur Behandlung der Beckenvenen- und Femoralisthrombose, Wien. klin. Wchnschr. **49**:1067, 1936.

At present the preference for surgical or for conservative treatment remains a matter of personal predilection. Both methods are effective in trained hands. Anticoagulants decidedly arrest clotting as long as the anticoagulant is administered, but they do not affect the thrombus already in existence and do not help attach the thrombus to the venous wall.

In either the surgical or the conservative treatment of venous thrombosis, the physician has always to take into consideration the fact that an old and well attached thrombus may become an embolic hazard by new appositional tail formation. General and local circulatory conditions have to be watched carefully in order that unnecessary accidents may be avoided.

SUMMARY

Stepping-stones in the research of thrombo-embolic disease are outlined.

The following aspects of thrombus formation are discussed: (1) the allergic factor ("Dietrich nodules") in thrombus formation; (2) the white plug and the red tail of a thrombus; (3) the fundamental biologic difference between the white plug and the red tail; (4) the significance of glucose distribution in thrombus formation; (5) the interaction of glucose and fibrinogen, and (6) phlebothrombosis and thrombophlebitis.

667 North First Street.

A COLOSTOMY BAG

New, Single Use, Disposable Bag with Individually Molded Collar

ADOLPH M. BROWN, M.D.
Associate, Illinois Eye and Ear Infirmary
CHICAGO

THE COLOSTOMY concept is one of the bravest and boldest in the history of medicine. This dramatic feat of physiologic engineering has saved countless lives, but the prospective possessor of a colostomy must view his future with disgust, especially since it is explained as inevitable. Anything to make his existence more tolerable is gratefully received by the patient.[1]

In addition to the possibility of surgical complications, such as prolapse or stenosis, the imperfections of control of loss of fluid, fecal loss and gas make life miserable for the patient even though colostomy is the method used to effect a possibile cure of a miserable disease. Even the best designed and executed colostomy opening is a severe household difficulty and social embarrrassment.

Interest in the rehabilitation of the colostomized patient is of great sociologic, economic and psychologic importance.[2] These patients have often remarked that occasionally the surgeon fails sympathetically to evaluate the plight of one faced with the problem of using a colostomy bag. It is most important that the surgeon remain interested in the patient and help him manage his colostomy opening.[3] In addition to giving proper instruction as to irrigation, diet and care of the skin, it is advisable that the surgeon actively supervise the selection of a bag or pad, as indicated by the case, and examine the ensemble for fit of belt, collar and bag.

The following points should be borne in mind:

The belt should be adjustable, should not rest or rub on the anterior superior iliac spine and should be easily detachable from the collar.

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1. McLanahan, S.: Aluminum Paste and Skin Protector in Enterostomy, J. A. M. A. **108**:385 (Jan. 30) 1937. Shedden, W. M.: The Management of Permanent Colostomies, New England J. Med. **206**:792, 1932.

2. Gevinaus, F. C.: Proctology, New York, D. Appleton-Century Company, Inc., 1936, p. 601.

3. Martin, C. F.: Stricture of the Rectum, J. A. M. A. **101**:1550 (Nov. 11) 1933.

The cup should fit snugly enough to prevent herniation and prolapse. It should not be rigid.

Present day bags, which the patient must empty, wash, dry and reapply again and again, are revolting even to the esthetically callous patient. The bags are made of rubber and, since they have to be used every day, must be cleaned by washing or boiling and, to prevent odor, must be turned inside out and aired.

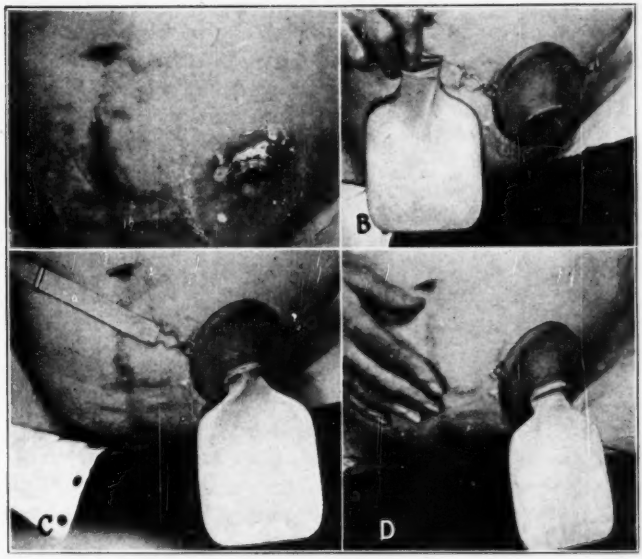

Fig. 1.—(*A*) A colostomy wound. The white areas surrounding the mucosa are flakes of colostomy bag cement. (*B*) The colostomy bag ensemble. The collar, sculpturally molded to fit the abdominal wall, is cemented to the skin with a special water-proof and perspiration-proof adhesive substance. It is further supported by an elastic belt, hooked as shown. The patient is holding the single use, disposable bag. (*C*) The single use, disposable colostomy bag in position. Gas escapes slowly through a small notch in the collar. (*D*) The colostomy ensemble cemented in place, without use of the elastic belt.

The purpose of this paper is to describe a colostomy bag with two significant features:

1. The bag itself is a single service container, to be used once and disposed of.

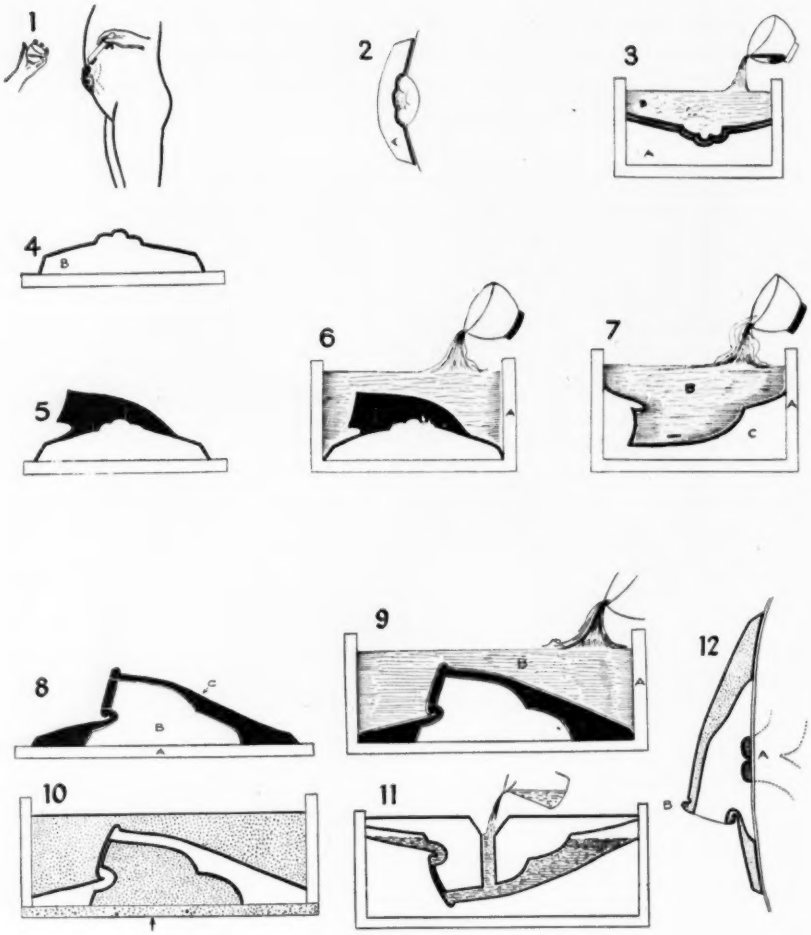

Figure 2

Fig. 2.—(*1*) An impression of the abdomen and colostomy area is obtained by applying an alpha gypsum mixture over the area, with the patient in the upright position. (*2*) The plaster of paris negative impression is permitted to dry and solidify. (*3*) The negative impression (*A*) is coated with separating compound and walled in "plasticine" or clay. It is then filled (*B*) with a plaster of paris mixture, which, when solidified, is separated from the negative impression. The negative impression is discarded. (*4*) The positive cast, or actual reproduction of the abdominal area bearing the colostomy opening, is thus made. On this, the colostomy bag collar will be modeled or sculptured. (*5*) The passageway, or core, of the collar is sculptured first, in clay, on the colostomy wound to form a positive impression. The black area thus represents the inside space, or core, of the colostomy ring. (*6*) Now a clay wall (*A*) is built around the clay core and plaster ensemble, and more alpha gypsum is poured over it to form a negative impression of the core. The negative is permitted to harden, and the positive impression of the area of the colostomy wound is temporarily set aside. (*7*) The negative just poured is turned upside down, a new clay wall (*A*) built around it, and more plaster mix (*B*) poured into its cavity. This forms a replica of the abdominal wall and the core of the colostomy collar. The plaster (*C*) is chipped away and discarded. (*8*) On the plaster base (*A*, here represented as flat) and plaster core (*B*), the collar is now sculptured in clay (*C*) around the plaster core. (*9*) Now a new clay wall is built around the plaster ensemble bearing its sculpture, and the mold is poured (*B*) with plaster to complete the mold. (*10*) This illustration represents the plaster mold and core, assembled after the clay has been washed out. Now, at the arrow a pouring channel will be cut through the back of the mold. (*11*) A liquid latex mixture is poured through the channel to complete the casting process. It will form a hollow collar, or ring, which will surround the colostomy wound and fit the abdomen exactly. It will support the neck of the colostomy bag, around its ring. (*12*) The completed colostomy collar is represented schematically in place. *A* represents the colostomy opening. The disposable bag fits over the ring (*B*). The ring (*B*) is also notched, but the notch is not represented. The notch permits accumulation of gas in the bag to be very slowly expelled spontaneously.

2. The collar of this colostomy bag is individually molded to fit the patient's abdomen at the site of the colostomy wound.

The bag is used once. When it is filled, it is simply removed from its collar, without contaminating the fingers, and dropped into the toilet bowl, to be flushed away. It is at once replaced with a duplicate, also without contamination of the hands. Bag replacements are carried in the pocket or purse and occupy no appreciable bulk.

As can be seen from the diagrams and photographs, the collar of this colostomy device is made by sculpturing its model directly on the plaster replica of the patient's abdomen. It is modeled directly over a cast of the colostomy opening, with its lumen varied to fit over the lips of the colostomy opening and the duct slanted downward to lead easily to the bag. Sculptors' clay is used for this purpose, as centuries of use have proved it as a modeling medium. Yet other materials, including pink dental wax or "plasticine," can be used for modeling.

The model is duplicated in natural rubber by the technic illustrated in figure 2. The collar will be found to adapt with a perfect fit into every configuration of the abdominal wall shouldering the colostomy wound. This fact is of special significance when one realizes that the colostomy site often is traversed with depressed or raised scars and, further, may be distorted by abdominal herniations. One such case is illustrated (fig. 3).

After one collar is sculptured, it can be used as a model for those of other patients.

It is difficult enough to please a patient with a colostomy opening by offering a colostomy bag. But, after he has tried stock bags, he shows gratitude indeed when this bag is offered. The feature of single service is gratefully received, and the idea of disposing of the bag without emptying it seems esthetically more desirable than what the patient previously has been accustomed to.

Once the bag is fitted, the patient has his choice of wearing the collar cemented to the abdominal skin, which measure insures a water-tight fit, or of supporting it snugly in place with an adjustable elastic belt. Or the patient may use both cement and the belt.

The bag fits over the flanged collar. The bulge is negligible. Patients who have formerly used the larger bags are grateful for this feature, for with it there is no telltale bulk evident through the clothing.

At present the bags are molded by dipping the positive plaster model into an aqueous dispersion of prevulcanized natural latex.[4] The cement

4. The bags will be mechanically molded soon by a commercial dipping process, using an aluminum mold and a coagulating agent.

used to seal the colostomy collar to the abdominal skin is a latex dispersion mixture, such as the following:

	Per Cent
Aqueous dispersion of latex (40%)	70
Zinc oxide	20
Storax	10
Oil of rose	

When the collar is cemented, the abdomen is cleaned with special care to eliminate oils or unguents from the skin. The inner face of the collar is painted with the cement, as is the corresponding area around the wound. It is then necessary to wait about half a minute until each surface is dry. All tackiness must be gone. Then, and not until then,

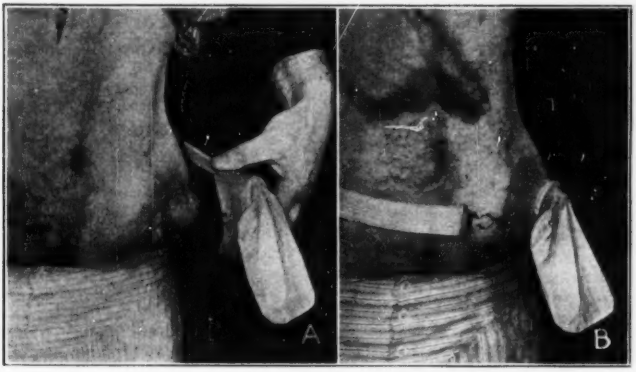

Fig. 3.—*A*, a colostomy collar sculpturally molded to fit a herniated abdominal site. *B*, the bag in place over the herniated area.

the collar is affixed to the site of the wound. The rubber adheres to rubber with a water-proof seal. Then the disposable bag is affixed to the flangelike neck of the collar.

One or two spare bags are kept in the pocket. An ordinary latex condom, everywhere available, may be used in an emergency. This ensemble was the first I devised. The spare bags are dusted within with a deodorant powder, such as that made by the following formula:

Zinc peroxide	35.0
Boric acid	20.0
Bentonite	10.0
Oil of rose	0.5
Talc	100.0

The powder also prevents adhesions of rubber within the bag.

1260 Lake Shore Drive (10).

Surgical Clinics

COMPLICATIONS OF INJECTION OF THOROTRAST IN THE CAROTID ARTERY

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WASHINGTON, D. C.

DR. BRIAN BLADES: A few weeks ago we saw in this clinic a case in which there was a mass in the neck and some manifestations of pressure, which apparently had followed an injection of "thorotrast" (colloidal suspension of thorium dioxide). Our interest has been aroused in this subject, and it is somewhat amazing to find that 3 similar cases are being observed in this hospital and 1 in the George Washington Hospital and that Dr. Bradley has also observed a case, which he will describe today. We shall have the privilege of hearing Colonel Berman, of Walter Reed Hospital, who, with his associates, has collected several cases.

The first case will be presented by Dr. Abrahams.

DR. HARRY ABRAHAMS: Mrs. C. S. is 38 years old and has had epileptiform seizures since the early part of March 1946. She was admitted to the Neurological Service in the course of one of these seizures in the latter part of March 1946, and a carotid arteriogram was attempted. Shortly after this attempt was made, she noted a mass on the right side of her neck, which she described to be about the size of a quarter. This mass has gradually increased in size since that time. It caused no symptoms until about two weeks ago, when she noted that it had become painful and tender to the touch. She also noted that her speech had become somewhat thicker and that she could not enunciate as distinctly as formerly.

Her epileptiform seizures have been recurring approximately twice a month, the last attack having occurred two weeks ago. She has been receiving "dilantin" (diphenylhydantoin sodium) therapy since admission.

The laboratory examinations revealed nothing significant. The reactions to the Kahn and Wassermann tests were negative.

The noteworthy features of the physical examination are confined to the neck, where a mass is palpable under the right angle of the mandible. It extends from the angle anteriorly and medially for a distance of approximately 8 cm., almost to the midline. The widest portion of the mass is posterior, being about 3 cm. in diameter. The anterior portion narrows down to between 1.5 to 2 cm. The mass is roughly pear shaped. Its surface is smooth, and its consistency almost woody. It is fixed and is not tender to palpation.

The roentgenologic findings of note are confined to the neck, where radiopaque material is scattered throughout the tissues, most of it being located under the angle of the jaw.

DR. BLADES: A second and somewhat similar case will be presented by Dr. Kelly.

DR. JAMES L. KELLY: A 21 year old white woman was admitted to Gallinger Hospital on Nov. 4, 1942.

The history indicated that while in school she had fallen off a chair and injured her head. One week prior to her admission headaches developed, and because of nuchal rigidity she was admitted to the Neurological Service, where a diagnosis of a cerebral aneurysm was made. It was believed that a carotid arteriogram was indicated. This was attempted unsuccessfully, and there was extravasation of "thorotrast" into the fascial planes of the neck. A carotid arteriogram was performed on the left side. After this there developed an acute inflammatory process in the neck; she was examined by members of the resident staff, who believed that immediate operation was not indicated. A hard mass

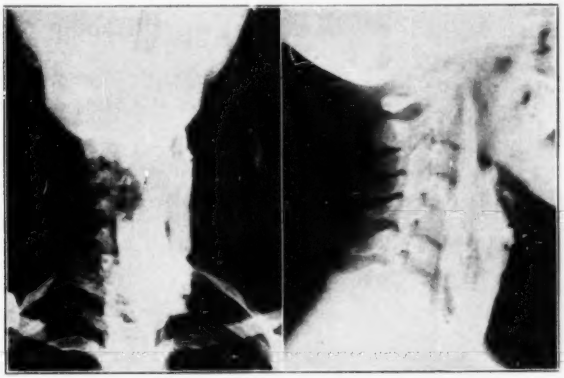

Fig. 1.—Radiopaque "thorotrast" in the neck extending upward into the region of the oral pharynx and downward into the superior part of the mediastinum.

has been present for the past four years in the left side of the neck. Increasing hoarseness has been present for one year. There has also been increasing dysphagia. The mass has been growing somewhat larger during the past few years.

Physical examination revealed no abnormalities except in the left side of the neck. There was a firm, fixed, smooth, stony hard, nontender mass extending from the submaxillary region down to the clavicle. The voice was hoarse. Examination of the heart, lungs, abdomen and extremities was noncontributory.

The past history was not remarkable except that two years ago material from a small lump in the right side of the neck was taken for biopsy at Emergency Hospital. Pathologic examination of this tissue was reported to show neurofibromatosis. Laboratory studies have revealed nothing abnormal.

You will note that there is extravasation of the "thorotrast" medium into the fascial planes of the neck in these three roentgenograms.

Roentgenograms of the neck (fig. 1) revealed a mass of opaque material in the left side of the neck, extending from above the level of the mandible downward into the superior mediastinum of the chest.

DR. BLADES: Dr. McCune, since you operated on this patient, will you describe your findings at operation?

DR. WILLIAM MCCUNE: Because of the fact that this patient had been complaining of progressive dysphagia, dyspnea and hoarseness with a gradually increasing firm mass in the left side of her neck, it was decided that a radical resection of all tissues containing 'thorotrast" should be performed. Consequently, with the patient under general intratracheal anesthesia and in the supine position with the neck extended, an incision was made from the tip of the chin to the left mastoid process, an extension being made downward to the suprasternal notch and laterally along the upper border of the clavicle. Skin flaps thus outlined were dissected back, which exposed the entire left side of the neck from the trachea to the trapezius muscle. Directly under the skin was a mass of firm, almost hard tissue infiltrating all the structures of the neck, especially about the carotid sheath. The mass extended downward below the level of the clavicle and upward above the larynx behind the ramus of the mandible. It was difficult to dissect out the different structures of the neck because all were infiltrated by the mass of tissue. The transverse incision above the clavicle was deepened down to the scalenus muscles, which exposed the trunks of the brachial plexus, the phrenic nerve and the internal jugular vein. By upward traction on the mass of tissue, it was possible to remove that portion of it which lay in the upper part of the thorax. It was carefully dissected off from the internal jugular vein and from the carotid artery. Directly over the common carotid artery was a small space which was free of the 'thorotrast" fibrosis. The internal jugular vein was divided at the upper border of the clavicle and the entire mass of tissue dissected upward off from the common carotid artery. The trachea was encased in a mass of the tissue, which was dissected with difficulty. The vagus nerve was completely involved and could not be saved. Consequently the left vagus nerve was sacrificed. The superior cervical sympathetic chain was dissected free. It was apparently unharmed. The left lobe of the thyroid gland was resected. The hypoglossal nerve was densely involved in scar. The scar was resected from the nerve and the nerve reanastomosed. The esophagus was carefully freed from the fibrotic process and the dissection carried upward to the region of the oral pharynx. The posterior wall of the oral pharynx was completely involved in fibrotic scar (fig. 2), and in the attempt to free this scar from it the pharynx was inadvertently opened. The scar was removed from all areas except a small patch on the posterior wall of the pharynx itself. The pharynx was closed with silk sutures in two layers. The entire mass of tissue was removed. The skin layers were closed with silk, two drains being left in the wound. The patient returned to the ward in good condition.

Postoperatively, there was a considerable degree of tracheal and laryngeal edema, which lasted for several days. This gradually subsided, the wound healed well and the patient is now symptom free. The hoarseness has not increased above that which she had before operation. There is a moderate degree of Horner's syndrome, apparently due to dissection about the cervical sympathetic chain. Postoperative roentgenograms (fig. 3) revealed no thorium-containing tissue except in the posterior wall of the pharynx. In that area only a small bit of radiopaque material can be seen.

DR. BLADES: The third case will be presented by Dr. Eastman.

DR. WILFRED EASTMAN: This is the case of Ida K., who sits before you. She came to this hospital a little over a month ago complaining of having had

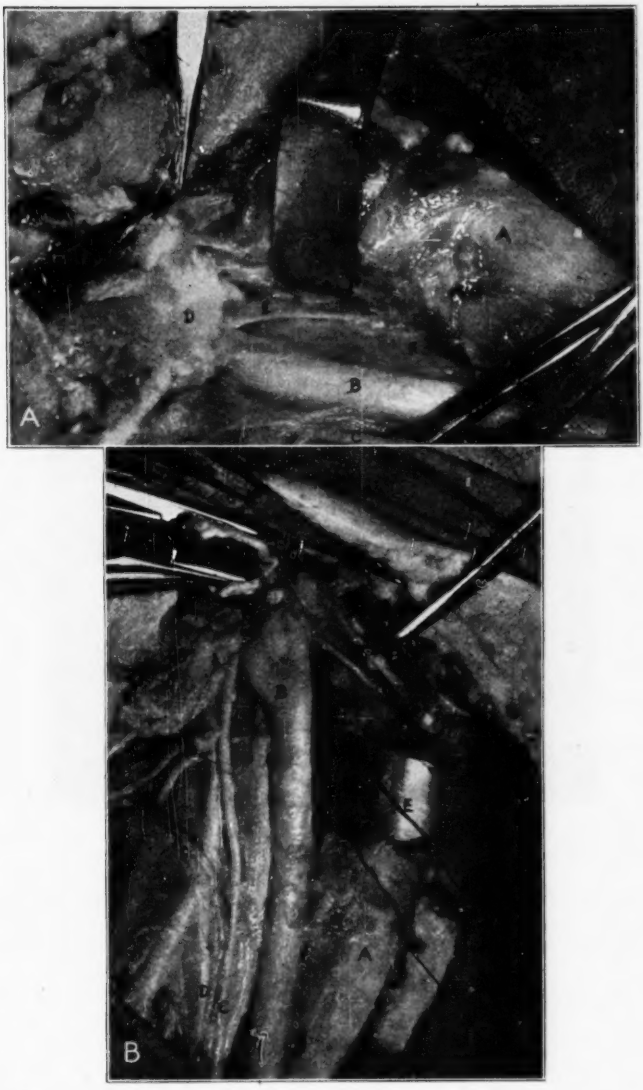

Fig. 2.—*A*, operative photograph showing (*A*) trachea, (*B*) common carotid artery, (*C*) cervical sympathetic trunk, (*D*) mass of "thorotrast" fibrosis with band of fibrous tissue, (*E*) extending downward between esophagus (*F*) and trachea. *B*, photograph after removal of fibrous scar tissue which extended into the posterior wall of the pharynx; *A*, trachea, *B*, bifurcation of common carotid artery, *C*, sympathetic trunk, *D*, phrenic nerve, *E*, suture beginning closure of pharynx.

unconscious spells. At the time of admission she was in just such a state. She had been having similar attacks for approximately three years and had never had them before that.

She was admitted to the neurological service for study. In the course of this study a carotid arteriogram was performed on the left side on Nov. 10, 1947, with the use of "thorotrast." This arteriogram, however, was not entirely successful, and postoperatively some roentgenologic evidence of extravasation of "thorotrast" into the tissues was discovered.

After the arteriogram was made she had some pain in her neck for approximately twenty-four hours, but after that there were no symptoms. There was no postoperative swelling, and no tumor could be felt. The remainder of the history is noncontributory except that she has hemorrhoids, for which she was transferred to the surgical service two days ago.

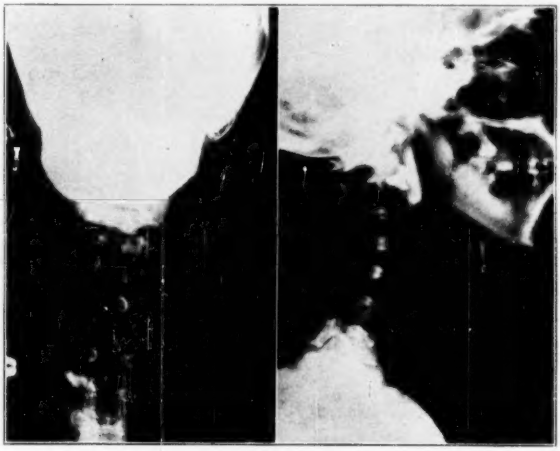

Fig. 3.—Postoperative roentgenograms of patient in figure 1 after radical dissection in the neck. "Thorotrast" has been removed entirely.

Her physical condition is otherwise normal except for mild hypertension and generalized arteriosclerosis. No mass can be palpated in the neck, and there is no localized tenderness. Hemographic and laboratory studies show no abnormalities.

This is the roentgenogram of the neck. It shows nothing in the mediastinum, but "thorotrast" is obviously present in the left side of the neck.

DR. BLADES: Three representative cases in which injection of "thorotrast" into the neck occurred have been presented. Dr. Tom Bradley has recently operated on a patient in whom "thorotrast" was used in the antecubital fossa. Dr. Bradley, will you please present your case?

DR. TOM BRADLEY: A girl was admitted to Children's Hospital in November 1935 for the removal of a large tumor mass beneath the right axilla. In an effort to diagnose this tumor mass, it was thought best to inject "thorotrast"

intravenously to see if the tumor filled. She had previously had an angiosarcoma in the same location, and we had been confused in the diagnosis. The tumor turned out to be a cystic hygroma.

At the time the "thorotrast" was injected into the cephalic vein of the right arm some was spilled into the tissues. I heard that it had been spilled, and, knowing that it was radioactive, I made a transverse incision across the antecubital fossa and attempted to get as much of it out as I could.

From then on, a mass developed at the site of the injection which slowly became larger and at times painful, especially after trivial injuries.

One week ago excision of this mass was undertaken. I made an incision which started in the upper part of the arm on the outer surface over the cephalic vein and extended down the arm and transversely across the antecubital fossa and then down the inner side of the forearm. The two flaps were reflected back, and I removed a mass of tissue of the consistency almost of bone, with some difficulty, and severed the anterior brachial cutaneous nerve, which has produced partial anesthesia extending down the forearm.

There have been no motor or sensory changes other than that. Examination prior to the operation had shown a perfectly normal forearm and hand. There has been no evidence of sloughing.

DR. BLADES: Dr. Klopp, of the Warwick Clinic, has consented to be with us today and to describe a case in which he has recently performed an operation.

DR. CALVIN T. KLOPP: The patient is a 60 year old Negro woman, from whom, incidentally, we have never been able to get a history of ever having had an injection of "thorotrast." She was admitted to the hospital with the complaint that six months previously she had had some dysphagia and hoarseness. About five months prior to her admission, some dimness of vision had developed in her right eye. Four months before her admission she experienced difficulty in breathing through her nose.

All these symptoms progressed until she finally presented herself at Episcopal Hospital, where examination revealed that she had a large nodular mass in the nasopharynx extending down the posterior pharyngeal wall until it could actually be seen beneath the uvula. There was nothing palpable in her neck. She had mild proptosis on the left side and moderate proptosis on the right.

She was sent to the Warwick Clinic after a diagnosis of malignant tumor was made. We also believed this diagnosis to be correct. However, twelve biopsies were performed, all of which showed chronic inflammatory change. Roentgenograms were taken of her skull. You will see two things. One line follows the carotid sheath, and in addition there is a destructive lesion seen at the base of the skull finely mottled with what was first thought to be calcium. The point was brought up that while this might represent some kind of chondrosarcoma it was difficult to explain on the basis of an injection of "thorotrast."

Because of the interest of one of the radiologists, we resected this portion of the carotid sheath which was somewhat fibrotic but otherwise did not look in any way abnormal. Specimens were sent to the Bureau of Standards, which verified the belief (1) that there was radioactivity which fogged a photographic plate and (2) that the radioactivity was alpha activity. They are also in the process of proving that it is thorium, but, as they put it, if it has activity it certainly is not uranium and it is not radium, so it must be thorium.

During the patient's stay in the hospital, she has lost the sight of her right eye completely and has almost lost the sight of her left eye. She has atrophy of the left optic nerve and papilledema in the right eye. It is difficult to know

whether or not anything can be done for her. One week ago she had an episode in which for twenty-four hours she was unable to be roused, and we thought we were going to solve the problem. However, she recovered spontaneously and has since been all right.

If there are any comments on this case, I should like to have them.

DR. ROBERT H. GROH: It seems to me that the progression of this woman's symptomatology, with papilledema in one eye and atrophy in the other, is typical of what is known as Foster Kennedy's syndrome, which is characteristic of a tumor of the frontal lobe. I should think that if she had had an injection of "thorotrast," some interested neurosurgeon must have attempted at that time to diagnose her original symptoms as indicative of a neoplasm. Foster Kennedy stated that certain tumors of the frontal lobe of the brain caused optic atrophy on the side of the tumor because of pressure cone and increased intracranial pressure caused choked disk on the opposite side. I would, therefore, be totally disinclined to regard the entire clinical picture in this case as due to an injection of "thorotrast" in the neck. Maybe "thorotrast" has worked up into the posterior nasopharynx, but everything need not be explained on the grounds of the use of this medium.

DR. THOMAS M. PEERY: I wonder if Dr. Klopp would comment on whether he thinks a neoplasm is present or not.

DR. KLOPP: It was our feeling that the destructive lesion in the base of the skull must be accounted for on the basis of some neoplasm and not on the basis of the injection of "thorotrast." The point which we brought up for discussion was whether this could be a neoplasm which is secondary to the presence of "thorotrast" over a long period. I believe a somewhat similar case was reported in which there was sarcoma in the spleen secondary to injection of "thorotrast."

DR. BLADES: We will leave this case, at least temporarily, and ask Dr. Peery to demonstrate microscopic sections from some of the cases which have been described.

DR. THOMAS PEERY: (Slide) This first slide is one prepared by Dr. Lindsay at Warwick Clinic from a cadaver in which thorium dioxide was injected into a muscle mass. There was no reaction of the tissue, since the injection was made in a dead body.

We are accustomed to seeing thorium in the liver and spleen, where it remains for a long time after it has been injected. (Slide) These are sections of liver and spleen. The hepatic cords are along in here, and the thorium is seen as these deposits clumped together along the perivascular spaces, replacing, apparently, parts of the hepatic parenchyma and, in the case of the spleen, some of the splenic pulp. In the liver it is characteristically collected in the Kupffer cells lining the sinusoids. In the spleen it is picked up by the large monocytes that are present everywhere in the pulp.

The other slides to be shown are from various cases, some of which have been discussed here. (Slide) The first one is from the collection made at the Walter Reed General Hospital. This is a Mallory stain. The thorium is present here in large deposits in big foamy mononuclear cells, comparable to the manner in which it is present in the liver and spleen in cases at autopsy.

DR. BLADES: Was this taken from the neck in a living subject?

DR. WILLIAM S. MCCUNE: Yes, I think so.

DR. PEERY: The remaining slides are from consecutive biopsies in Dr. Klopp's case, and I believe they are of somewhat more interest.

(Slide) This is material presumably from the nasopharynx, although there is no tissue by which to recognize it. There is no epithelial surface. There is an active inflammatory process, with extensive necrosis. Fibrin is deposited all through the tissue. That is material taken for the initial biopsy (fig. 4 *A* and *B*) and, if you recall, we do not know when the patient received thorium or whether she received it at all. Whatever she received, it is radiopaque, at least in the roentgenogram, and has radioactivity.

(Slide) This material, taken for a second biopsy (fig. 4 *C*), has a necrotic surface which may or may not be significant, but you will notice that there is considerable epithelial proliferation dipping down into the granulation tissue.

I would like to try to get a higher magnification of this one because it does show one other point of interest. The most significant change, I believe, in this more long-standing lesion is the tremendous proliferation of small blood vessels. Each of these small nests scattered through here, more or less rounded, is a small capillary, and it can be seen that they are greatly increased in number even if they cannot be recognized with certainty on the screen. Not only are these increased in number, but the lining cells are tremendously thickened. They represent pronounced hyperplasia of the endothelium of the small capillaries.

(Slide) Here is material from a still later biopsy (fig. 4 *D*), and you will note a change from the previous section in which the capillary and endothelial preparation is so pronounced. Here there are tremendous numbers of small vessels, but they are dilated and thin walled, comparable to those that develop in the skin and subcutaneous tissues after irradiation therapy. Changes such as these are to be found in the skin of the breast after irradiation or in the tissues of the abdominal wall after external irradiation has been given for cancer of the cervix. There is also considerable scarring here.

(Slide) The last slide I want to show you is again from Dr. Klopp's case, and this one has some areas that appear to me to be strongly suggestive of neoplasm. The cell type is suggestive of neurogenic sarcoma. It is certainly not an epithelial tumor.

DR. BLADES: Colonel Amory and Colonel Berman, of the Walter Reed General Hospital, have collected a rather large series of cases in which "thorotrast" has been used in the neck. Colonel Berman will present these cases and will tell us the conclusions which he and Colonel Amory have reached.

COLONEL HARRY L. BERMAN: I should like to preface these remarks by saying that the study on the perivascular injection of "thorotrast" and its sequelae was done by Colonel Amory and Dr. Bunch. I had nothing to do with the work, and my only relation to this matter is my appearance here to represent Colonel Amory and Colonel Bunch, both of whom are in Boston at the meeting of the Radiological Society of North America, where they are presenting this same paper. I will not cover the entire paper because part of it is related to a review of the literature, which I think would be redundant here.

A series of 7 cases of perivascular injection of "thorotrast" was recently studied at Walter Reed General Hospital, and the results of the study will appear in an early issue of *Radiology*. Perivascular injection of "thorotrast" in 6 of the cases resulted from attempted cerebral angiography and in the seventh from attempted injection into the brachial artery. In 1 case the injection was made directly into the exposed carotid artery, but in spite of this large amounts of "thorotrast" were found in the perivascular tissues.

In the first case which appeared the condition had been previously diagnosed as myositis ossificans because of the roentgenologic appearance. A history of an

injection of "thorotrast" could not be obtained in this case. The patient had severe pain in the right side of the neck, torticollis and marked dysphagia and dyspnea because of fibrous constriction of the trachea and esophagus. Examination revealed large, firm, tender masses in the right side of the neck, with fixation of

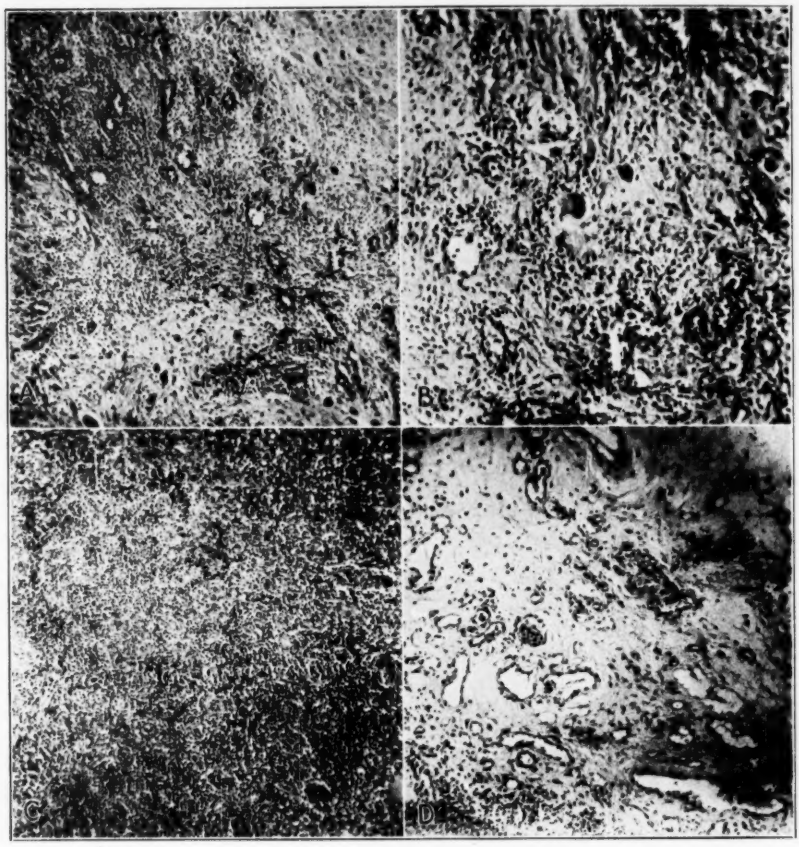

Fig. 4.—Photomicrographs of tissue removed from patient in figure 1. *A* and *B*, early reaction, showing increased vascularization, giant cells and round cell infiltration about granules of "thorotrast"; *C*, a later section showing increasing infiltration by lymphocytes and early fibrosis; *D*, advanced reaction, with dense fibrosis about foreign body granules.

soft tissue. The trachea was deviated to the right, and the esophagus was constricted to such an extent that the patient could swallow solid foods only by flexing her neck.

Roentgen examination showed that the "thorotrast" had extended down into the mediastinum and along the posterior pericardium almost to the diaphragm. Tissue removed at operation performed to free the esophagus and trachea was placed on a photographic film, and a radioautograph was obtained which proved the presence of radioactive material. The tissue from this and from a second case was analyzed at the Las Alamos Scientific Laboratory, Las Alamos, N. Mex., and found to be definitely alpha active. Spectographic studies proved the presence of thorium in the tissues.

Three of the 7 patients have symptoms causing disability; in 2 these are definitely contributable to the presence of "thorotrast" in the soft tissues. Two patients have symptoms possibly due to the presence of "thorotrast," and 2 have no complaints. The patients who have been followed up for long periods have symptoms, whereas symptoms have not developed in those who have been followed for a shorter period.

It is known that "thorotrast" contains 20 per cent thorium dioxide by weight, and, compared with radium the radiation from 75 cc. equals 1.5 to 3 micrograms alpha activity, insignificant beta activity and 0.9 micrograms gamma activity. The ratio of tissue toxicity is alpha 10,000, beta 100, gamma 1.

It is believed that the patients who do not have symptoms will eventually have symptoms and perhaps disability as found in the others.

It was concluded that the prognosis in a case in which "thorotrast" is present in tissue should be guarded and that at no time is it justifiable to consider the highly ionizing alpha radiation from "thorotrast" in amounts now used as innocuous. The potential dangers accompanying the use of "thorotrast" far outweigh the slight advantage of the greater radiopacity, and its use as a contrast medium in clinical radiology should be discontinued.

DR. BLADES: The evidence seems to be accumulating that "thorotrast" is perhaps dangerous and certainly has significant radioactive properties. Dr. Gerwig has investigated this problem purely from the clinical standpoint and will probably have something to tell us.

DR. WALTER H. GERWIG JR.: Thorium is always accompanied with radiothorium. At present there is no known chemical method for separating thorium and radiothorium during the process of extracting and recovering thorium from monazite. The half life of thorium is 1.39×10^{10} years. We must consider that as degradation products are given off there is a fluctuation in radioactivity of the substance and as original radiothorium is dissipated to some extent there is a reaccumulation of new radiothorium. After a period of forty years the radioactive equilibrium is again restored in practically the same proportion as in the original substance. In other words, there is an undulation in intensity which may best be understood whenever one knows that some of the thorium changes to mesothorium and the alpha activity is decreased to some extent. Then mesothorium in turn will break down into radiothorium with increased alpha content. Therefore, it seems that there are alterations which strike an equilibrium over a period of about every forty years.

In this long-lifed element, which for all intents and purposes may be considered to exist ad infinitum, we find another interesting feature. Thorium emits alpha, beta and gamma rays similar to those of the radium series. In radium therapy the alpha and beta particles are filtered out and it is the gamma rays which are responsible for therapeutic effects. In thorium the gamma and beta rays are rather insignificant, and it is to the alpha rays that we attach the greatest significance.

These alpha rays are ten thousand times as toxic as the gamma rays responsible for the therapeutic effects of radium.

To recapitulate, we have a drug whose life activity would project its dissipation into millions of years in the future and which emanates alpha particles of extreme toxicity. Even though there is an undulation in its effect, there are periodic intervals during its life activity when original radioactive equilibrium is restored. On account of these factors, I think that we are dealing with an extremely dangerous substance.

DR. BLADES: Of course, an important point to consider in a discussion of this drug is its distribution in the body. Dr. Gerber!

DR. LEON GERBER: I should like to summarize briefly its distribution in the body. In the first place, according to Yater, about 75 cc. of thorium solution is used in the average case. That follows a pattern of about 0.5 cc. per pound of body weight. This is the amount necessary to obtain an adequate hepatosplenogram. The solution has been absorbed in the bloodstream within fifteen minutes of the time of its successful injection. It is then distributed to the elements of the reticuloendothelial system, mainly to the liver and spleen, the lymph nodes and the bone marrow.

One can, as has been indicated, trace this with a Geiger counter and, in the case of the spleen and liver, by roentgen examination. As far as we are able to tell, the substance remains in situ indefinitely. Only a small proportion, the exact amount of which is evidently not determined, is excreted by the kidneys.

DR. BLADES: Dr. Pearl Holly has a real and active interest in radiopaque materials and has had the advantage of association with various members of the Carnegie Geophysical Laboratory. Perhaps Dr. Holly will make some remarks about the pure physics of this substance.

DR. PEARL B. HOLLY: I have, rather, a few remarks to make about the hematologic effects of this substance, and then I shall quote Dr. Urry's remarks about its radioactive assay.

About two and a half years ago we had a case of aplastic anemia in a 53 year old Negro woman; she died about five days after her admission to the hospital. Microscopic examination revealed thorium dioxide deposited in the liver and spleen. She had not given us a history of a previous admission to the hospital. After the autopsy findings were reported, we examined the hospital records and found that she had been admitted ten years previously because of abdominal pain. At that time cirrhosis of the liver was suspected, and she had received thorium dioxide intravenously (presumably about 75 cc.).

Physical examination on this last admission, in 1944, revealed two nodules on both antecubital fossas which were about 3 cm. in diameter, firm, freely movable and not attached to the underlying or overlying tissues.

A portable roentgenogram was taken on her third day in the hospital. It was reported to reveal a small contracted spleen, and, as you can see here, there was an accessory spleen. This report was put on the chart after death, and the significance of the visualized spleen was overlooked. This was verified at the postmortem examination. The spleen weighed 15 Gm. and was small and contracted and on microscopic section thorium dioxide was found in the spleen, liver and bone marrow.

We sent specimens of tissue to Dr. William D. Urry at the Geophysical Laboratory at Carnegie Institute, who assayed their radioactivity. He reported that

the amount of radioactivity which was there would, when present internally in the body in constant irradiation, produce tissue damage such as that which was present. The bone marrow was markedly hypoplastic. This case was reported by J. Spier and others in the *Journal of Laboratory and Clinical Medicine* (**32**:147, 1947).

Previous reports of "thorotrast" affecting the hematopoietic system have not been numerous, though more might be expected from the numbers who have received this material. Evidently, the so-called resistance of the host is important, and different persons react in different fashion.

Dr. Klopp referred to the case of sarcoma of the liver which was reported by McMann and Murphy in the *Archives of Pathology* two or three months ago. In their case sarcoma of the liver was found near the area of greatest concentration of "thorotrast." Their patient had received the preparation twelve years previously. She had not been in the hospital long enough for a hematologic study but came in and died in the admitting office. Her bone marrow was hypoplastic.

Dr. Urry's reports of radioactivity are similar to those of the Las Alamos group in that most of the activity was due to the alpha particles. Alpha particles ordinarily do not cause trouble when administered externally because they do not penetrate the tissues; nevertheless, when implanted in the body, they are a constant source of irradiation and therefore produce the same effect as the gamma rays.

Dr. Blades: Dr. Groh just made a remark to me that he felt like Little Red Riding Hood among a pack of wolves, which is synonymous with saying that he is a lone neurologist among a group of surgeons. We will now ask him to defend himself.

Dr. Robert H. Groh: The neurologist in many ways has been a "guesser," for he is faced many times with the problem of deciding whether a person suffering from intracranial disease should or should not undergo the rather extensive operative procedures involved in neurosurgical treatment. By means of the carotid arteriogram, we are frequently able to make the decision, since often types of intracranial tumors can be disgnosed preoperatively in this way. The vascular pattern that is seen is an indication of whether the tumor is a glioblastoma, a meningioma, an astrocytoma or some other type of tumor that has a particular vascular pattern. The neurologist frequently needs the information obtained from a carotid arteriogram.

Many times the diagnosis of intracranial disease can be made more accurately by this means than by an air encephalogram. We have used "thorotrast" since its introduction when attempting to gain this knowledge. It is true that in the first several years of experience with it the patients occasionally had "thorotrast" injected into the neck while a carotid arteriogram was being made. If the technic is performed accurately, this need not occur in the direct puncture of the carotid artery. It is a procedure that requires a certain amount of experience and skill, but this is not difficult to acquire. I do feel that "thorotrast" need not be injected into the perivascular tissues of the neck.

When faced with serious neurologic disease, I wonder whether it makes any difference if a patient has "thorotrast" in his liver and spleen for fifteen years. Does this matter, if we are able to get information of diagnostic value to tell the patient or his family or both about his intracranial disease?

There are several iodine preparations that have been used in arteriography of all parts of the body, and particularly the head. Use of these requires an open incision

in the neck and an exposure of the carotid artery because the highly concentrated, sclerosing substances of the iodine type can produce their own damage in the neck if they are injected extravascularly.

We have attempted to avoid this exposure as much as possible. Whether the results at this clinic warrant a revision of our thinking remains to be seen. Certainly, one cannot deny the facts that have been presented here today in reference to "thorotrast." Whether or not it is necessary in some instances to have the highly definitive picture that "thorotrast" can give as compared with the iodine preparations is a problem that only the neurologist and the neurosurgeon can answer. Our idea now is that if the diagnosis of malignant glioblastoma can be made the patient should not undergo extensive neurosurgical treatment. How can this diagnosis be made without a procedure as accurate as arteriography?

The technic which is essential in giving an accurate intracarotid arterial injection without thorotrast being spilled in the neck requires a needle, a three way stopcock, a 20 cc. syringe and on the side arm of the stopcock a piece of rubber tubing with a smaller, maybe a 10 cc., syringe.

The puncture into the artery is made with the needle, with the stopcock so turned that the force of blood will come back into the empty syringe. The 20 cc. syringe contains the "thorotrast." When we get blood under pressure into the empty syringe, we force it back in, holding the needle in place. If a mass forms in the neck, the needle is not fully in the artery, and 2 or 3 cc. will produce a swelling along the carotid sheath. This mass can be felt and seen. The blood can be reinjected. We let it come back again and force it in a second time, and if then there is still no swelling in the neck, we presume that the needle is in the carotid artery. So long as the needle does not move while the stopcock is being turned, it seems to me that the intra-arterial injection of the "thorotrast" can be accomplished without any difficulty.

DR. BLADES: Dr. Groh, you have done a splendid job of holding the wolves at bay, at least temporarily. Apparently these accidents with "thorotrast" are not new. They have been known. We have simply had the good fortune of seeing a number of cases lately. Dr. Iovine has reviewed the literature concerning the history of "thorotrast" and may have something to add in that respect.

DR. VINCENT IOVINE: Thorium itself was discovered by Berzelius in 1819. There is little else in the literature, from a medical point of view, until about 1907, when a pharmacologist named Sollman investigated its properties in various animal experiments. About the same time, a physiochemist named Hahn discovered mesothorium, one of the radioactive components that is under discussion today. In 1912 numerous German investigators attempted further clinical investigation using animals.

It is interesting to note that in 1915 a resident urologist at Johns Hopkins Hospital (Burns), who was searching for a more radiopaque substance for outlining anomalies of the genitourinary tract, used thorium itself in combination with other salts and outlined the genitourinary tract in some 200 cases without subsequent complication.

The first use of thorium dioxide, I believe, was instituted by two workers in their separate fields. Oka, a Japanese, found, when he was experimenting with thorium dioxide, that some roentgenograms of rabbits into which the substance had been injected outlined the spleen and liver. He apparently failed to interpret the results from a radiologic point of view. In the same year, 1928, a German in Berlin named Paul Radt, working at the Pathological Institute, used thorium

dioxide to outline the liver and spleen in animals and correctly inferred that the outline was the result of the affinity of thorium dioxide for the reticuloendothelial system. In the same year he first used the substance to outline the liver and spleen in human subjects. This investigator at first applied his discovery to the outlining of foreign bodies in the spleen or liver in animals, and he deduced that probably the substance could be used to outline tumors, other types of new growth or more pathologic variations in the liver and spleen.

In this country, as you know, Dr. Yater started using thorium dioxide for hepatosplenograms in 1933 and, I believe, in 1943 reported its use in several hundred cases.

It is also interesting to note that in the thirties there were numerous articles in the German literature referring to the carcinogenic properties of thorium dioxide in animals, and there are frequent articles referring to granulomatous processes appearing in the body when the substance was infiltrated into the tissues in an extravascular manner.

DR. BLADES: Dr. Iovine has mentioned Dr. Yater's work, and I am sure all of you know Dr. Yater. During the period of his pioneer work, Dr. Weinstein was a resident in this hospital. Have you some remarks about Dr. Yater's early experience?

DR. J. J. WEINSTEIN: One of the first reports in 1933 described his technic for using this dye as a diagnostic procedure for lesions in the liver and the spleen. He at that time listed some twelve or thirteen indications for the use of "thorotrast" as a diagnostic medium. He used it in the diagnosis of carcinoma of the liver, hepatic abscesses or lesions above the liver, lesions below the liver, unknown palpable masses, cirrhosis and other types of hepatic disease and jaundice and for the determination of certain primary diseases in the spleen.

In his later reports he changed his procedure somewhat as he began to investigate more carefully. About 1936 he rather limited his use of the material to the diagnosis of tumor masses primarily in the liver, and he had found that his roentgenograms of the spleen were not too diagnostic as far as primary disease was concerned. He could visualize mainly size and not so much metastasis or changes within the spleen itself. Since that time, in still further reports, he has limited his scope of diagnosis primarily to hepatic abscesses, cysts in the liver and metastatic lesions.

He uses the drug chiefly in instances in which it is of serious importance to diagnose abscesses, especially those of amebic origin, and secondly when there may be primary tumors of the liver or a metastatic carcinomatous lesion that is not recognized clinically before surgical intervention. The diagnosis of such lesions beforehand would certainly help in the care of the patients. As Dr. Groh has pointed out, it is an important diagnostic measure when it is necessary to eliminate certain types of surgical procedures.

DR. BLADES: Since this technic of diagnosis is so important, it would be of interest to explore the possibilities of agents which might be satisfactory and perhaps less dangerous. Dr. Harrell!

DR. J. BLAINE HARRELL: During the past decade, angiography has become an important and widely used diagnostic procedure. Two types of radiopaque solutions are used in this community. These are (1) "thorotrast" and (2) "diodrast," an iodine-containing preparation.

"Thorotrast" is preferred because it gives sharp contrast and shows fine detail. Its potential dangers have been emphasized during this session. However, many, particularly those who study cerebral angiograms, believe that the advantages

of "thorotrast" justify the hazards. Actually, each of the granulomas discussed here was caused by a preventable technical error. Practice and improved skill should reduce such occurrences. I have recently observed Dr. Groh make an injection into a carotid artery. His precautions would seem to make perivascular infiltration impossible.

"Diodrast" renders contrast which is entirely adequate for angiocardiograms and for studies of the vessels of the extremities. It has the distinct advantage of being rapidly excreted. Thus its use can be repeated, which permits the taking of views from different angles and allows progress studies to be made. Escape of "diodrast" into perivascular tissues seldom causes more than a mild inflammatory reaction.

DR. BLADES: From the standpoint of the surgeons, the primary problem concerning the patients whom we have seen today is: Can we do anything for them surgically, and, if we can, what is the surgical objective? I believe Dr. Richtmeyer has explored the possibilities of surgical excision in the type of case described.

DR. DUANE C. RICHTMEYER: Since "thorotrast" is a radioactive substance and eventually causes fibrous tumors when it is placed outside of the blood vessels in tissue, I believe that it should be removed from those places into which it has been extravasated, although usually this will necessitate a block dissection of the area involved.

DR. BLADES: We have seen today 3 patients in whom "thorotrast" has accidentally been injected into the tissues of the neck. On our own service here we have 4 cases in which this occurred. These with Dr. Bradley's case and the Walter Reed series make a total of 13 cases in which thorotrast has caused untoward results. In 11 instances the material has been injected into the neck and in 2 into the antecubital fossa.

ORTHOPEDIC SURGERY IN THE ARMY AIR FORCES DURING WORLD WAR II

III. Psychologic Problems, Convalescent Care and Rehabilitation

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PSYCHOLOGIC PROBLEMS

THROUGHOUT World War II, it was repeatedly urged that all medical officers learn psychiatric principles. Menninger [1] stated: ". . . whether a medical officer is a battalion surgeon, or an orthopedist in a hospital, a dispensary physician or an induction board examiner, he will have numerous occasions when he must exercise psychiatric judgment. Probably more truly than in civilian life, every medical officer is faced with personality deviations." Military orthopedic surgeons soon came to realize there was no alternative to learning more about the psychiatric aspect of orthopedic problems. A steady stream of patients presenting psychogenic musculoskeletal symptoms was referred to orthopedic sections. In the beginning, the disability in

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1. Menninger, W. C.: Opportunities for Treatment of Neuropsychiatric Patients, Bull. U. S. Army M. Dept., March 1944, no. 74, p. 90.

many of these patients was labeled organic, and they were given long periods of hospitalization and intensive orthopedic therapy, which occasionally included surgical treatment. Gradually the true character of the disability in these patients was discovered. As time passed and experience widened, general practitioners and orthopedists learned of more proper evaluation, treatment and disposition. Such things as personality structure, emotional maturity and neurotic reactions came to have new meaning. A few medical officers were carried away by the psychosomatic approach and erroneously saw a psychogenic basis for some clearly organic diseases. After considerable groping and study, most military orthopedists expressed the belief that they had found the middle of the road. Many stated the opinion that for the first time in their professional careers they were systematically treating patients with orthopedic disability in their entirety, as human beings, and not merely as animated skeletons. Orthopedic surgeons, as well as all other clinical specialists, were stirred to the realization that the psychiatric aspect of their specialty could no longer be ignored or dealt with only by intuition.

How frequently were symptom-producing psychologic problems encountered on an orthopedic service? A survey of all patients hospitalized on one large orthopedic service [2] for a period of one year disclosed that 11.1 per cent had psychologic problems which were either the sole cause or the most important contributing cause of the musculoskeletal symptoms necessitating hospitalization. Among the orthopedic outpatients of that same orthopedic service during that same year, the disability in 25 per cent was predominantly psychogenic.

In a study on the medical service of an army general hospital (Hoff) Boland and Corr [3] observed that of 450 consecutive cases in which the diagnosis was arthritis or an allied organic condition, "psychogenic rheumatism" was the most frequent cause of disability. At another army general hospital (Tilton) Saxe [4] reported that "functional muscular disability comprises over 50 per cent of cases admitted to this hospital as organic neurologic disease. The most common entities for which this psychogenic manifestation is mistaken are spinal cord tumor, herniated intervertebral disk, peripheral neuritis, brain tumor, and degenerative diseases such as multiple sclerosis and syringomyelia."

2. Luck, J. V.: Psychosomatic Problems in Military Orthopaedic Surgery, J. Bone & Joint Surg. **28**:213, 1946.

3. Boland, E. W., and Corr, W. P.: Psychogenic Rheumatism, J. A. M. A. **123**:805 (Nov. 27) 1943.

4. Saxe, E.: Functional Muscular Disabilities: Their Recognition and Treatment, Bull. Menninger Clin. **8**:59, 1944.

Based on relationship to an organic lesion, three types of psychogenic cases were seen on the Army Air Forces orthopedic services: (1) those in which no relevant organic lesion could be uncovered, either in the past or present, (2) those in which psychogenic problems were secondary to organic lesions and (3) those in which psychogenic problems perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint the disabilities were divided into: (1) conversion reactions, (2) anxiety or tension states and (3) elaborations (psychogenic elaboration of symptoms from an organic musculoskeletal lesion). Various combinations of these types were commoner than pure types.

This report is based on detailed observations of more than 1,000 cases in which the psychogenic factor was the cause of musculoskeletal symptoms. Most of the patients were not confirmed psychoneurotic persons. The disability in many was classified by the psychiatrists as simple adult maladjustment, meaning, in most instances, that the patient had remained adjusted emotionally for most of his life but had succumbed to what had been to him overwhelming physical stresses, usually incident to military service. To see such large numbers of these cases was a new experience both to psychiatrists and orthopedists. As Murray [5] pointed out, "The short span of time in which individuals go from health to neuroses and back to a reasonably healthy state again is completely foreign to civilian experience."

Psychologic History.—On many orthopedic services, an abbreviated psychologic history was taken in all cases in which the source of symptoms was obscure and when inadequate objective and laboratory evidence existed to explain the subjective symptoms. The long comprehensive history taken by psychiatrists requires considerable time to take and much experience to interpret; such a study is essential only for the understanding and evaluation in complex cases. An abbreviated psychologic history can be taken readily by any physician, along with the regular clinical history. After such a study a psychologic disorder will not often be perpetuated by being diagnosed and treated as an organic entity or, just as bad, denied all treatment because no organic lesion is identified. Menninger [6] outlined an abbreviated neuropsychiatric examination. Army Air Forces flight surgeons employed a similar survey. These examinations included a series of questions to bring out the patient's adjustment to life in general, to the Army, and to his occupation, his school, his family and his friends. The degree of emotional maturity (personality structure) was ascertained and a basis secured on

5. Murray, J. M.: Psychiatric Evaluation of Those Returning from Combat, J. A. M. A. **126**:148 (Sept. 16) 1944.

6. Menninger, W. C.: A Condensed Neuropsychiatric Examination for Use by Selective Service Boards, War Med. **1**:843 (Nov.) 1941.

which the patient's ability to make future adjustments could be evaluated. General intelligence of the patient was estimated, as was also the character (organic or psychogenic) of past and present somatic symptoms. The questions pertaining to family history included questions to bring out the presence of psychologic problems in members of the patient's family. An evaluation of the soldier's motivation and morale was essential. The capacity of poor motivation and low morale to precipitate psychologic problems was impressive, but not any more impressive than the ability of proper motivation and high morale to cure and to prevent psychosomatic symptoms. Gordon [7] stated, "More people are sick because they are unhappy than unhappy because they are sick." Many were the factors in military life during the war which caused resentment, hostility and anxiety in emotionally immature persons. Growing anxiety often resulted in neurotic physical symptoms. Soldiers with poor physical resistance did not await combat conditions to present a neurotic reaction, but often presented a psychosomatic problem in the first few months of service. These soldiers could not withstand regimentation and steady hard monotonous work, plus the denial of home life, luxuries and old friends. Their despair and resentment gave rise to frustration and conflicts, which ushered in mental depression and disturbed sleep. Sleeplessness plus long hours of hard work led to chronic fatigue, more insomnia and more anxiety. The soldier then frequently met an adverse situation that was "the straw that broke the camel's back" and dramatically converted his emotional chaos into physical symptoms, which, when manifested in the musculoskeletal system, often led to hospitalization on an orthopedic service. Such soldiers had a low threshold of conversion.

Analysis of Psychogenic Musculoskeletal Pains.—A clue to the functional origin of psychogenic musculoskeletal pain frequently came from coaxing the neurotic person to describe his pains accurately. At the outset he usually described his physical distress as being simply a pain, just as did the patient with an organic lesion. On further questioning, the so-called pain was often found to be a feeling of tightness or of pressure or there was a localized area of intense fatigue or a "dead" feeling. Extremities were described as feeling numb or asleep or as though one or more of them were missing. There was no position of complete relief, and immobilization often aggravated the distress. Bizarre patterns of radiating pain also characterized many neuroses. One of the most frequent psychogenic radiations went from the coccyx or sacral region to the upper part of the back or the occiput. Pain radiating from a distal point proximally was more often of functional origin than pain which radiated distalward.

7. Gordon, A.: Modern Conception of Neuroses, J. Nat. M. A. **36**:121, 1944.

Sites of Neurotic Musculoskeletal Symptoms: While no parts of the musculoskeletal system were observed to be exempt, there were certain sites which were particularly susceptible to becoming foci of neurotic symptoms. These favored sites were the sacrum, coccyx, knees, feet, neck and shoulders. The site of a healed fracture or operative scar not infrequently was the somatic focus into which the neurotic person channeled the expression of his emotional stresses.

Although in some instances it was impossible to uncover an explanation of the particular site at which symptoms occurred, in a high percentage of patients combined orthopedic and psychologic histories identified the focus of neurotic symptoms as being the site of previous organic symptoms either in the patient himself or in some one close to him, i. e., his mother, father or brother.

Objective Observations in the Neuroses: In some instances the physical examination revealed no positive observations, and in others it disclosed many. The more frequent objective observations were: (1) circumferential hypalgesia (better known as stocking and glove anesthesia), (2) hysterical paralysis, (3) vasomotor instability, (4) hyperhidrosis, (5) hyperactive reflexes, (6) camptocormia (forward bend of the spine), (7) astasia abasia (able to sit and to move about well in bed but unable to stand or walk) and (8) coarse intention tremor of an extremity. It must be emphasized that a clinical picture was not considered to be psychogenic on the basis of any solitary symptom, but only after weighing all objective and subjective observations.

Circumferential Hypalgesia: One of the most significant objective evidences of a neurosis, and one of the most frequently overlooked, was the presence of nonanatomic areas of diminished sensation. Although conversion hysteria rarely produced anesthesia and analgesia, it frequently was associated with production of hypalgesia. There usually was a diminished response to heat and cold as well as touch and pain, but no test was so satisfactory for identifying the levels of diminished sensation as the pinprick test for pain. When there was hysterical hypalgesia of overlying skin, there was similar hypalgesia of such deep structures as the periosteum and synovia. In testing sensation, every precaution was taken to avoid suggesting a response to the patient.

One hundred consecutive patterns of circumferential hypalgesia were recorded on the sketches by Luck.[2] This series portrayed the wide variation in the patterns and also the high proportion of patients with multiple sites of involvement. Of the 100 patients, 90 showed multiple sites of nonanatomic hypalgesia, 72 having some degree of involvement of all four extremities. Changes were confined to the right side of the body in 11 patients and to the left in 4. In 52 patients part or all of the head was involved. The site of subjective symptoms frequently

appeared unrelated to the pattern of hypalgesia. Hysterical paralysis was present in 9 of the patients and in all instances was confined to one of the extremities.

Psychosomatic Backache: Psychogenic back pain was observed to be (1) a part of a conversion reaction, (2) the result of nervous tension in an anxiety state or (3) an elaboration of organic symptoms of the back. Although various combinations of these types were commoner than pure types, one factor usually stood out above the others. In the analysis of consecutive cases of psychogenic pain in the back, the condition in approximately one third proved to be the result of anxiety states, in one third it was a symptom of a conversion reaction and in a third it was an elaboration of organic symptoms of the back. The patients with tension states had pain at one or more tension or fatigue points in the spine (lumbosacral junction, middorsal region and upper cervical and occipital regions). Pain in the conversion reactions was widespread and generally associated with pain radiating from the coccyx to the neck and also with circumferential hypalgesia. Camptocormia was present in 3 of the patients with conversion reactions. The elaboration symptoms represented actual exaggeration of the existing organic symptoms or superimposed conversion and tension symptoms. A lumbosacral lesion was the most frequently associated organic impairment.

Treatment and Disposition: The psychiatrists took over the complex psychologic problems, but for a large group of patients, particularly those with combined psychogenic and organic musculoskeletal symptoms, the orthopedists had to assume the responsibility for the psychotherapy. Just as there was an acceptable abbreviated psychologic history, there was worth while abbreviated psychotherapy—usually referred to as superficial or minor psychotherapy. It included: (1) evaluation and advice regarding the correction of environmental conflicts, (2) the giving of insight into the character of the existing psychologic symptoms, together with an explanation of coexisting organic symptoms, (3) identification and elimination of the underlying conflict when possible and, when this was not possible, the elimination of aggravating factors, (4) the administration of sedatives when there were insomnia and chronic fatigue and (5) the prescription of occupational therapy when indicated. Insight was not given until the patient's confidence was secured—as the psychiatrists said, "until rapport was established."

Some soldiers experienced functional symptoms only under the most profound and prolonged mental and physical stresses. In such men the response to treatment and the prognosis were much better than in persons in whom neurotic episodes developed during ordinary stresses of life.

During treatment for organic lesions every effort was made to detect and correct bad psychologic trends and incipient neurotic reactions. In general the earlier the neurotic symptoms were treated, the better the response and prognosis.

Prior to elective surgical treatment, patients were carefully evaluated psychologically. This procedure proved to be eminently worth while. As Wechsler [8] has said in referring to unwarranted surgical treatment of neurotic persons, "Heroic operations do violence to patients and confirm their neurosis."

Soldiers with neurotic musculoskeletal symptoms were urged to carry on and were firmly informed that their work would do their musculoskeletal system no harm—rather the giving in to every symptom was one of the real sources of harm.

Giving intensive mechanistic therapy for neurotic musculoskeletal symptoms proved to be harmful and often fixed and perpetuated the symptoms. Halliday [9] emphasized that, "With increased facilities for mechanistic diagnosis and therapy, there is danger, if relevant considerations are omitted, of inducing 'fixation invalidism' on a scale hitherto unknown." This error was made all too frequently. In large numbers of soldiers with neurotic musculoskeletal symptoms, physical therapy procedures were carried out almost endlessly. On several orthopedic services, where psychosomatic problems were not properly differentiated from organic problems, numerous patients were seen who had received protracted periods of hospitalization with such diagnoses as lumbosacral and sacroiliac strains, traumatic osteoarthritis, synovitis and sprains. A wide variety of orthopedic procedures were carried out in these patients, including surgical treatment. During the latter part of the war, a wider understanding of psychosomatic problems was apparent in the greatly reduced number of psychologic problems labeled with musculoskeletal diagnoses.

ORTHOPEDIC CONVALESCENT CARE AND REHABILITATION

Medical care in World War II, with its emphasis on improved convalescent care and rehabilitation, showed great advancement. Each branch of the service, beginning with the Army Air Forces, developed an extensive and far reaching convalescent rehabilitation program. Orthopedic convalescent care and rehabilitation were a large and important part of these programs. The high plane of the present concept of this aspect of orthopedic surgery is due in no small degree to knowledge gained during the war.

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8. Wechsler, I. S.: A Textbook of Clinical Neurology, ed. 5, Philadelphia, W. B. Saunders Company, 1943.

9. Halliday, J. L.: The Rising Incidence of Psychosomatic Illness, Brit. M. J. **2**:11, 1938.

Previous to the war, with the exception of scattered small groups of workers, it was the accepted policy during immobilization of extremities or the spine to allow atrophy of muscles and stiffness in joints to proceed unchecked. At the end of the period of immobilization the patient, with his flabby muscles and stiff joints, was given physical therapy, usually for many weeks, which consisted of baking and massage plus passive stretching of the joints.

In orthopedic rehabilitation, as it is now practiced, the muscles are contracted actively from the outset, regardless of the type of immobilization, and when the period of immobilization ends, vigorous resisted active joint motion replaces passive stretching. It was discovered that if proper care was given to the muscles, the joints took care of themselves.

Orthopedic rehabilitation proved to be much more than the giving of systematic resisted exercises; it also required treating the patient psychologically. Sources of anxiety were legion, but many were anxieties anticipated and relieved before they created a disabling burden of nervous tension.

The fundamental aspects of orthopedic rehabilitation are: (1) repetition, (2) resistance, (3) reassurance and (4) sequence of exercises, the power stage, the mobility stage and the coordination stage.

Repetition.—In the preservation or restoration of musculoarticular function, nothing proved to be more fundamental than the frequent repetition of exercises. Elaborate heating apparatuses, whirling water and massage had their place, but they did not build strong muscles. At the outset, the patient was made to understand that rehabilitation could come to him only by his own efforts; rehabilitation cannot be "spoon fed."

On most of the orthopedic services a program of active exercise was instituted the first day following an operation or a fracture. Waiting several days or "until the stitches are out" generally was discovered to be a mistake. In the case of elective surgical treatment, the detailed instructions and demonstrations of the postoperative exercise routine were presented to the patient preoperatively.

Notwithstanding widespread impressions to the contrary, it was learned that exercises can be carried out effectively and systematically inside the largest plaster of paris cast or in the most complex traction. Good circulation was maintained, healing stimulated and stiffness of joints, atrophy of muscles and impaired coordination reduced to a minimum. Patients were informed that each muscle group must be forcefully contracted and exercised, just as though the joints were free to move. Instructions were given regarding the location and function of the various impaired muscle groups, so that the soldier could systematically exercise each group in turn. For example, with a foot and

leg encased in plaster of paris, the foot was plantar flexed, dorsiflexed, inverted and everted with progressively increased firmness against the inside surface of the cast. The cast had to fit sufficiently snugly to prevent unwanted mobility of fracture fragments and joints. If a cast became loose, the space between the cast and skin was packed, and if this was not feasible a new cast was applied.

The question often arose as to whether exercises should be carried out for thirty minutes once a day or for "five minutes every daylight hour." In most instances a combination of these two methods of exercise was found to have much to recommend it. A widely employed routine consisted of a ten to thirty minute period of vigorous effort and instruction once a day, supplemented by a five minute period of exercise every daylight hour. In late stages of convalescence, when most of the exercises were carried out in a gymnasium and in the occupational therapy department, the exercise period every hour was not so essential.

One of the finest of the several rewards that came to the patient for the frequent repetition of exercise routines during orthopedic convalescence was the prevention of impaired coordination. Immobilization without exercise (passive immobilization) resulted not only in atrophy of muscles and stiffness of the joints but also in damage to the patient's ablity to coordinate the movements of the immobilized joints. Highly skilled movements were the first to go, but, with longer periods of passive immobilization, even such fundamental unconditioned reflexes as the cylindric grasp frequently became so impaired as to suggest paralysis.[10] Through many painful experiences it was learned that loss of coordination was infinitely easier to prevent than to restore.

Resistance.—The second fundamental in orthopedic rehabilitation proved to be that exercises must be carried out against progressively increasing resistance. Muscles increase in strength in direct proportion to the demands placed on them, so that in retaining or regaining muscle strength it was imperative that the muscles be given an increasingly heavy load. It is a well known law of nature that increased demand and function of a part of the body bring increased capacity for work, and, conversely, when function ceases the capacity to function steadily diminishes and ultimately may be lost.

Resistance to muscle contraction was supplied in a multitude of ways. The simplest of all methods was the use of agonist against antagonist. Since muscles of locomotion are paired, one balancing the action of the other, it was possible to exercise one muscle against its opposite. This form of exercise involved no appreciable movement of the joints, making it an excellent resistance technic for muscles inside casts and in certain types of traction. After practice, patients learned

10. Nicoll, E. A.: Rehabilitation of the Injured, Brit. M. J. **1**:501, 1941.

that strong resistance could be supplied to the muscle contractions; the fatigue following periods of this form of exercise was testimony to the energy expended. Watson-Jones [11] pointed out that Sandow, once the world's strongest man, utilized this method to attain his great strength. Elaborate apparatus was not always available, but, fortunately, was not essential for carrying out resisted exercises; the only essentials were bags of weights, rope and pulleys, a knowledge of anatomic structure and a passion for preaching "the gospel of rehabilitation." [12] The weight of the body itself frequently served as the source of resistance, e. g., in deep knee bends, push-ups and pull-ups.

There does not appear to be nearly so much danger of damaging weak muscles by overloading them as orthopedic surgeons had been taught to believe. Now, after the broad war experience in systematically employing heavy resistance exercises, it can be said with confidence that this is the most effective and the most rapid method of restoring weak atrophied muscles to their normal dimensions and strength. No harm was observed from pushing a weak muscle to do its utmost against all of the resistance against which it could move. If there were minute hemorrhages and ruptured muscle fibers, they did not assert themselves in any conspicuous manner. During heavily resisted contractions and relaxations, care was taken to prevent jerking, contractions being made smoothly and slowly. Heavy weights were built up to gradually, and complete relaxation between lifts was emphasized.

Minimal resistance free-swinging exercises had a place, but only after muscles were sufficiently strong to protect the joints from the strains and sprains that were so liable to occur from excessive joint motion when muscles were weak.

A convenient and effective source of resistance for bed exercises proved to be the stretcher made either with springs or elastic rope. When springs were not available, strands of elastic rope were stretched between a pair of handles. Such home-made stretchers were cheap enough for each bed patient to have his own to exercise all free extremities and his neck.

When skeletal muscles were not exercised during periods of immobilization, circulatory changes occurred in the immobilized joints, which frequently led to permanent damage. Joints that became stiff during immobilization did so more because of circulatory impairment than because of lack of joint movement. There is a "pumping action" [13] from

11. Watson-Jones, R.: Fractures and Joint Injuries, ed. 3, Baltimore, Williams & Wilkins Company, 1944.

12. Rusk, H. A.: The Army Air Forces' Convalescent-Rehabilitation Training Program (First Year's Experience), J. Indiana M. A. **36**:649, 1943.

13. Griffiths, H. E.: Treatment of the Injured Workman, Lancet **1**:15, 1943.

muscle contractions in that during contraction the veins are compressed and the blood pressed proximally on its way to the heart. Bainbridge (1931)[14] demonstrated experimentally that the quantity of blood circulating through a muscle increases four to nine times during exercise. During passive immobilization the venous stasis developing in the encased joints may ultimately lead to an edematous, inflexible joint capsule, fibrin extravasation, atrophy of the articular cartilage and adhesions.

Reassurance.—There was a steadily increasing appreciation and understanding of this phase of rehabilitation throughout the war. Imparting reassurance, it was soon learned, required something more than giving the soldier a pat on the back. Orthopedists were stirred to the realization of the tremendously important psychologic aspect to orthopedic rehabilitation. Whereas, most orthopedists formerly depended almost entirely on their intuition, they learned during the war to employ a scientific and sytematic approach, because of the efforts of the psychiatrists.

Insight into their medical problems was reassuring to most patients. When the diagnosis, treatment and prognosis were shrouded in mystery, the patient had innumerable anxious hours. When soldiers understood why they were required to carry out laborious and monotonous routines, they were far more willing to cooperate and were far less likely to present a psychologic problem.

No substitute was found for daily personal contact with the patient; a friendly patient-physician relationship was indispensable. One source of stimulation for both patient and physician was in the keeping of good records in the form of graphs, in which the strength, circumference and joint motion of extremities were plotted. Patients would strive earnestly to keep their graphs on the upswing.

Arranging patients with similar orthopedic problems together and establishing a spirit of rivalry went far in building morale and minimizing boredom. Every effort was made to create a spirit of optimism and good cheer in the wards. When weather permitted, outside activities were encouraged, and they did much to inspire and reassure.

Bad psychologic trends and lapses of morale were easier to prevent than to correct. A strenuous effort was made to veer soldiers away from regarding themselves as invalids; this was accomplished in part by treating them as "wounded athletes," and not as sick patients. The secondary gains from illness were often considerable, and it was necessary to keep in mind that there is a human tendency to drift toward the security of being dependent on others.

14. Bainbridge, cited by Griffiths.[13]

During ward rounds each patient's morale was checked along with the orthopedic examination. If there was a lapse in morale, something was generally done about it. When there were family or financial problems, and this was common, the Red Cross often was turned to for valuable assistance.

When the prognosis appeared bad, it was learned by bitter experience that it should not be discussed with the patient until it was ascertained that it truly was bad, and even then such a prognosis needed to be presented tactfully and in an optimistic light. For example, there were many instances in which much harm was done by telling a patient with a serious injury of the joint that arthritis would develop in the joint. When the word "arthritis" was used at all, orthopedists learned that they should quickly point out that it would not be the destructive arthritis (rheumatoid) familiar to the laity. Innumerable patients with traumatic arthritis were encountered who were in constant anxiety for fear that at any time the "arthritis" would spread from joint to joint and make them invalids. Such anxiety in a "bread winner," already partly incapacitated, was observed frequently enough to precipitate neurotic symptoms. Many disabling neurotic reactions on this basis could have been prevented.

Sequence of Exercises.—In the process of becoming rehabilitated, most patients passed through three stages: the first, the power stage, with its emphasis on building up muscle strength; the second, the mobility stage, in which maximum effort was directed toward restoring a full range of joint motion, and, third, the coordination stage, in which muscles and joints were helped to function with precision.

Obviously there was considerable overlapping in these stages, but it proved helpful to speak in terms of stages in order to emphasize the steps the patient must take in climbing the ladder of rehabilitation.

Power Stage: Often joint mobility was methodically avoided during the initial stage, and this was especially true directly following surgical treatment for a joint. Of course, in the presence of a cast, immobility of the encased joints was enforced. Atrophied muscles were built up sufficiently to protect the joints which they controlled before wide ranges of joint motion and walking were permitted. Multiple strains and sprains occurred and increased joint fluid resulted when mobility of the joint was emphasized prior to restoration of the muscles; a good example of this was seen repeatedly following operation on the knee joint when excessive walking was indulged in before the strength of the quadriceps muscles was restored. Unfortunately, it was a common error to consider such knees in need of more immobilization.

In the instance of elective surgical treatment for the joint, rehabilitation was instituted preoperatively with instructions and demonstra-

tions. The patient was taught to control the specific muscle groups most likely to atrophy postoperatively. It was gratifying to learn that by starting the exercises promptly, it was possible to prevent much of the deterioration of muscles and stiffness of joints formerly regarded as inevitable.

At the outset, the weight of the extremities afforded all of the resistance the muscles could move against, and occasionally it was necessary temporarily to remove the force of gravity; but as more resistance was tolerated, more was added. Bags of weights were employed to advantage, and the weights used were lead balls, scraps of steel, dumbbells and so forth. Bags were made of heavy cloth or leather and had padded straps to place over the top of the foot or to grasp with the hand. At the end of convalescence, surprisingly heavy resistance could be negotiated, e. g., a quadriceps muscle often was able to extend the knee against 50 to 100 pounds (about 23 to 45 Kg.) of resistance. De Lorme [15] employed York bar bells to advantage. Occasionally the injured extremity became stronger than the uninjured, and this was observed to be decidedly advantageous in the case of rupture of the anterior crucial ligament. Weight rope-pulley arrangements were particularly valuable for the upper extremities, but were not always satisfactory for lower extremities.

Mobility Stage: During this intermediate stage the emphasis was on restoring joint mobility, but the "power program" was continued and the growing muscle strength was depended on to increase the range of motion. Passive stretching was virtually abandoned by most Army Air Forces orthopedists. Supervision was necessary that muscle strength and endurance be kept a little ahead of the increasing range of joint motion. Better function was derived from a joint with moderately limited mobility and strong activating muscles than from a fully mobile joint moved by weak muscles.

Many standard gymnastic procedures and types of equipment were used to good advantage, e. g., rowing machines, indian clubs, adjustable steps and high and parallel bars. Occupational therapy also had an important place in the mobility stage.

In such an active program of rehabilitation, it was inevitable that an occasional eager patient would go beyond the amount of exercise indicated and incur a brief period of increased pain in the joint, muscle spasm and decreased motion of the joint. Such reactions occasionally caused alarm, but need not have; after a day or two of rest, the program of exercise generally could be resumed. If after particularly strenuous exercise, no increase in pain or decrease in joint mobility appeared by the following day, it was concluded that the exercise was well tolerated.

15. De Lorme, T. L.: Restoration of Muscle Power by Heavy Resistance Exercises, J. Bone & Joint Surg. **27**:645, 1945.

Coordination Stage: In the final stage of orthopedic rehabilitation, the emphasis was on restoring precision of function. Conditioned reflexes were brought back into play, and smooth graceful mobility was sought. Occupational therapy was observed to be of the greatest benefit in improving coordination. Gymnastic equipment was also employed, as were games, calisthenics and ward duties.

Limping and malpostures were carefully observed, to prevent their becoming habits. At the earliest possible moment that a natural gait and posture became possible, the patient was persuaded and prodded into assuming them.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1946

A Review Prepared by an Editorial Board of the American Academy of Orthopaedic Surgeons

VI. CONDITIONS INVOLVING THE HIP JOINT

Prepared by
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NIEBAUER and King,[271] stimulated by the reports of Burns and Watson-Jones, performed arthrodesis of the hip by internal fixation with the Smith-Petersen nail and the additional insertion of a 3½ inch (9 cm.) venable screw from the inner surface of the ileum, in the region of the anterior inferior iliac spine, into the femoral head to increase the rigidity and strength of the fixation. The exposure is similar to that used by Smith-Peterson for hip arthroplasty. The fixation is performed with the hip at a 35 to 50 degree flexion. Impaction insures earlier union. In 15 of 24 cases a painless stable hip was obtained, and in 7 motion and pain were present. There was infection of the wound in 1 instance, and 1 patient died after pulmonary embolism. Three of the failures were due to fractures of the "vitallium" nail, and in another case the nail penetrated the pelvis too deeply and pulled out. Aseptic necrosis of the femoral head was thought to be a contributing factor in the unsuccessful results in 2 cases. Fracture of the nail is less likely to occur if stainless steel nails are used.

Patrick[272] performs arthrodesis of the hip for osteoarthritis with the patient under spinal anesthesia, using a Smith-Petersen nail and a fibular graft. Three twist drills of different diameters, ½ inch (1.27 cm.), 7/16 inch (1.12 cm.) and 3/8 inch (0.96 cm.), used for making a tunnel for the graft, are needed to correspond to the possible variation in the size of the fibula. They are inserted over a guide pin. The guide should be withdrawn when the nail has been driven in 2 inches (5 cm.). This procedure has been found useful in the treatment of aseptic necrosis of the femoral head following pin fixation.

Freiberg[273] stated the belief that the basic principle of the Brittain ischiofemoral arthrodesis of the hip is sound. He performed the

271. Niebauer, J. J., and King, D.: Arthrodesis of the Hip (for Arthritis) Produced by Internal Fixation, J. Bone & Joint Surg. **28**:103-112 (Jan.) 1946.

272. Patrick, J.: Pin and Graft Arthrodesis for Osteo-Arthritis of the Hip, Lancet **2**:9-11 (July 6) 1946.

273. Freiberg, J. A.: Experiences with the Brittain Ischiofemoral Arthrodesis, J. Bone & Joint Surg. **28**:501-512 (July) 1946.

operation on 7 patients. In 4 of the 6 patients operated on for tuberculosis fusion occurred in seven to nine months; in another it occurred after one year. A full thickness tibial graft from the same leg, including the medial and anterolateral surfaces, was used.

Kleinberg [274] discusses the etiology, pathologic changes, symptomology and treatment of incipient slipping of the upper end of the femoral epiphysis. He advocates elimination of the epiphysial plate by drilling in an attempt to secure early fusion of the femoral head and neck. Freedom from weight bearing may be necessary for one to two years, or until the epiphysial plate has disappeared and bone lamellas extend from the neck into the head, denoting good union. The patient is kept recumbent with plaster immobilization for three months postoperatively, after which time the cast is changed and ambulation on crutches, with a single hip spica, is allowed. This is usually worn for three months, when the patient is provided with a brace for the hip.

In a study of 100 cases of slipped capital femoral epiphyses, Finch and Roberts [275] found 2 cases that were of the epiphysial coxa valga type, with a well formed acetabulum, which they believe are the first reported in the English literature. The authors were opposed to forcible manipulation in internal rotation, as they thought that degenerative changes resulted in 1 of their cases from this maneuver. [ED. NOTE (J. J. F.).—The authors point out that no lateral roentgenograms were made. This would be important in determining the relationship of the head to the neck.]

Foley [276] believes that a slight backward rotation of the femoral head can be accepted in a case of slipped femoral epiphysis, as it will not appreciably affect subsequent function. He advocated the use of the Smith-Petersen nail in the early stages. When the epiphysial displacement has passed beyond the acceptable limit, he suggests subtrochanteric osteotomy, accepting some uncorrected deformity rather than risking aseptic necrosis resulting from osteotomy of the femoral neck. [ED. NOTE (J. J. F.).—In the cases in which preslipping symptoms and sudden displacement have occurred, it is possible to obtain a satisfactory result by gentle manipulation and pin fixation.]

For the preslipping and minimal states of slipped femoral epiphyses, Sullivan [277] advocates drilling of the femoral neck across the epiphysial

274. Kleinberg, S.: Incipient Epiphyseolisthesis of the Hip, Am. J. Surg. **72:** 190-201 (Aug.) 1946.

275. Finch, A. D., and Roberts, W. M.: Epiphyseal Coxa Valga: Report of Two Cases, J. Bone & Joint Surg. **28:**869-872 (Oct.) 1946.

276. Foley, W. B.: Treatment of Slipped Upper Femoral Epiphysis: President's Address, Proc. Roy. Soc. Med. **39:**201-212 (Feb.) 1946.

277. Sullivan, R. F.: Slipping Epiphysis of Head of Femur in Growing Children, Bull. New England M. Center **8:**78-84 (April) 1946.

cartilage plate and the insertion of match grafts, as described by Howorth. It may be possible to have the patient ambulatory in one month when this type of treatment is instituted, and early union is obtained. His second choice is the insertion of a Smith-Petersen nail, as used by Philip Wilson. Operative procedures devised for advanced cases are given a guarded prognosis. [Ed. Note (J. J. F.).—The author's second choice of treatment in the preslipping and minimal slipping stages or pin fixation is usually favored.]

Luzuy [278] reports satisfactory results in 7 of 14 cases of degenerative arthritis of the hip in which treatment was by obturator pelvic neurectomy. The pain disappeared, walking became easier and mobility was increased, especially in regard to abduction, in the patients who responded favorably to treatment. Tavernier reported satisfactory results in 38 per cent of his cases when the same procedure was used and in 70 per cent when the crural branch was included in the excision. The increased abduction resulting from the neurectomy may be important in influencing the results, as the pressure forces are changed. Patients having pain on the inner aspect of the thigh, adductor contracture and bilateral involvement and patients who are poor risks are especially good candidates for this procedure.

Papin and Lafargue [279] expressed the opinion that none of the usual methods of treatment for chronic painful arthritis of the hip is satisfactory. Resection of the obturator nerve, suggested by Camitz twelve years ago, fell into disfavor because of the numerous failures. The authors realized that the hip is also supplied by the sciatic and crural fibers, and in 1943 they suggested total sensory denervation. Nine of 10 patients who underwent resection of the obturator nerve at the first stage and resection of the remaining nerve supply at a second operation are free from pain when resting and walking. Tavernier has had successful results with the same procedure in 90 per cent of 24 patients.

Padovani [280] discusses resection of the obturator nerve in the therapy of coxarthria and states that the percentage of cures is not high. It is more suitable for patients with flexion and adduction contractures, in aged persons with minimal deformity and in cases of bilateral disease in which there is good motion. It is often a useful adjunct to other surgical procedures. [Ed. Note (L. D. B.).—Neurotrophic joints have been reported after this procedure.]

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278. Luzuy, M.: Results of Treatment of Fourteen Cases of Coxarthria by Section of Sensory Nerves, Mém. Acad. de chir. **71**:221-225 (May-June) 1945.

279. Papin, E., and Lafargue, P.: Total Sensory Denervation of Hip in Chronic Painful Arthritis, J. de méd. de Bordeaux **121-122**:330-336 (June) 1945.

280. Padovani, P.: Resection of Obturator Nerve in Therapy of Coxarthria, Semaine d. hôp., Paris **22**:139-141 (Jan. 28) 1946.

Diez [281] performed radicotomy of the third and fourth lumbar roots for the relief of pain in a case of arthritis deformans of the hip. The patient was free from pain, and the muscular contracture had disappeared, which permitted good motion.

Judovich and Nobel [282] suggest that the pain in osteoarthritis of the hip may be due in some instances to involvement of the periarticular structures, particularly the tendons of the gluteus minimus and medius and the pyriformis muscles. Patients exhibiting tenderness in the area of insertion of these tendons may be relieved by local infiltration of procaine hydrochloride.

O'Brien, Shy and Bublis [283] report on 103 consecutive cases of trochanteric fractures of the femur in which treatment was by internal fixation. In their early cases, in which they used local anesthesia, there was a mortality of 43.4 per cent. The use of a combination of pentothal sodium and nitrous oxide reduced the mortality to 8.8 per cent. The authors used a Kirschner wire as a guide and inserted the nail under roentgenographic control. The Neufeld nail plate was used in 90 cases, the Moore plate in 8 and the Smith-Petersen nail with the Thornton attachment in 5. They prefer the Neufeld nail because it follows the guide pin more accurately and has less tendency to pull out. One nail broke after three months when the patient walked and another in one year when the patient fell. Medial protrusion of the plate into the hip occurred in 10 of the earlier cases. If the end of the plate is ½ inch (1.27 cm.) from the articular surface, this complication will be reduced. There was a mortality of 21.4 per cent, as compared to a 39.2 per cent mortality, reported by Leydig and Brookes, for 302 trochanteric fractures treated conservatively at the St. Louis City Hospital and reported several years previously. The results were excellent in 40 per cent of the cases, good in 22 per cent and fair in 16 per cent; in 22 per cent the patients were unable or unwilling to bear any weight, and the results were classified as poor.

Speed [284] stresses Pauwel's principle of measuring the degree of the obliquity of the fracture plane in relation to the horizontal plane in the determination of the method of treatment and the prognosis in fractures of the femoral neck. A truly impacted or abduction fracture in which the angle is 30 degrees or less between the horizontal line

281. Diez, J.: Treatment of Pain in Arthritis Deformans of Hip by Means of Posterior Radicotomy of Third and Fourth Lumbar Nerves: Case, Bol. y trab., Acad. argent. de cir. **29**:841-842 (Sept. 5) 1945.

282. Judovich, B., and Nobel, G.: Relief of Pain in Osteoarthritis of the Hip Joint, Am. J. Surg. **72**:72-73 (July) 1946.

283. O'Brien, R. M.; Shy, J. C., and Bublis, N. J.: Internal Fixation of Trochanteric Fractures of the Femur, J. Bone & Joint Surg. **28**:791-797 (Oct.) 1946.

284. Speed, K.: Subtrochanteric Osteotomy for Ununited Fracture of the Neck of the Femur, Ann. Surg. **124**:576-585 (Sept.) 1946.

and the fracture line offers a good prognosis. If the head is necrotic, one of the reconstruction operations is indicated. For a living head, osteotomy and plaster immobilization offers encouraging results. One fatality occurred from pulmonary embolism among 10 patients varying in age from 62 to 78 years when this procedure was used. The remaining 9 patients have slight shortening, and some can walk without a cane.

Hall and Berg [285] report on 14 patients, ranging in age from 59 years to 86 years, with nonunion of the femoral neck; some had aseptic necrosis of the femoral head and were subjected to a McMurray osteotomy and plaster immobilization. All were considered unsuitable for more serious surgical procedures, such as fusion or reconstruction. All had limited hip motion, especially with respect to internal rotation. Stability was uniformly satisfactory, with most of the Trendelenburg signs eliminated. Hip flexion to 90 degrees was obtained, and pain was minimal. No walking splints or other aid, except elevation of the shoe, is necessary.

Henderson and Henderson [286] discuss bone grafts for ununited fractures of the femoral neck and describe in detail the technic used in articular osteosynthesis and in the extra-articular method. The bone graft was used in the treatment of ununited fracture of the femoral neck in 90 cases between the years 1913 to 1945. This represents only about 1 in 10 patients admitted to the hospital for nonunion. In the past twenty-five years the percentage of cases in which union was obtained has been satisfactory, and the functional results in those cases have been gratifying. In the past ten years extra-articular operation in which a fibular bone graft has been employed has been adopted in the majority of cases. Among 24 cases of extra-articular osteosynthesis, excellent results were obtained in 12, good results in 4 and fair results in 1. There is little shock, and the procedure can be employed for older patients. A sufficient portion of the neck and a viable head must be available.

Inclan [287] believes that poor reduction, improper fixation, circulatory disturbances and infection are responsible for the late complications of fractures of the femoral neck. He advocated internal fixation with a bone graft in all cases of subcapital fracture and for early circulatory

285. Hall, C. L., and Berg, C.: Osteotomy for the Treatment of Ununited Fracture of the Femoral Neck, J. Internat. Coll. Surgeons **9**:20-35 (Jan.-Feb.) 1946.

286. Henderson, M. S., and Henderson, E. D.: Bone Grafts for Ununited Fracture of the Neck of the Femur: A Report of Ninety Cases, J. Internat. Coll. Surgeons **9**:26-34 (Jan.-Feb.) 1946.

287. Inclan, A.: Late Complications in Fractures of the Neck of the Femur, Treated by Nailing, Bone Grafting, or Both, J. Internat. Coll. Surgeons **9**:36-50 (Jan.-Feb.) 1946.

changes in the neck and head. Of 47 patients with fracture of the femoral neck treated only by nailing with the Smith-Petersen nail and followed for more than a year, 3 have had nonunion and 3 have had late complications, giving an incidence of poor results in 19.1 per cent. Among 21 patients treated with the use of a bone graft and a Smith-Petersen nail, complications developed in only 9.5 per cent of those followed for one year.

[ED. NOTE (J. J. F.).—It would be necessary to have a longer follow-up study in order to determine the merit of the method advocated.]

Venable and Stuck [288] have developed an operation consisting of a muscle flap transplant to the femoral head and neck to relieve symptoms of "aseptic necrosis" and painful osteoarthritis. Only 1 of the 27 patients who underwent the operation failed to obtain striking relief from pain. A flap from the medial half of the vastus lateralis is dissected free and transplanted into a slot cut in the neck of the femur, extending from the base of the head to the trochanter. [ED. NOTE (J. J. F.).—It would be interesting to see if just cutting the slot in the bone would give the same result.]

Crile [289] describes 3 cases of so-called hernias of the adductor muscles of the thigh. In 2 of these cases the operation had been performed previously after diagnosis of hernia, and it had failed in both. One of the patients was reoperated on and the protruding muscle excised. In the third case no previous operation had been performed and the pathologic process was clearly demonstrated. This condition has been found to be the result of ruptured adductor muscles, usually caused by a heavy blow or a sudden strain. When the ends of the muscles retract, the upper end retains its innervation, continues to function and contracts itself into a thick mass on the upper inner aspect of the thigh. The mass disappears when the muscle is relaxed and reappears when it is contracted. Hernias, however, occur at a point where the cutaneous nerves penetrate a congenital defect in the fascia. They may be multiple, and a history of trauma is usually not obtained. The author feels that correction of the deformity cannot be accomplished by repair of a supposed defect in the fascia. In early cases, repair of the muscles may give a satisfactory result. Conservative treatment and reassurance are recommended. If the presence of the mass is objectionable from a cosmetic standpoint, it can be excised, but not with complete assurance that the symptoms will be relieved.

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288. Venable, C. S., and Stuck, W. G.: Muscle Flap Transplant for Relief of Painful Monarticular Arthritis of Hip, Ann. Surg. **123**:641-655 (April) 1946.

289. Crile, G., Jr.: Traumatic Rupture of Adductor Muscles of the Thigh, U. S. Nav. M. Bull. **46**:719-723 (May) 1946.

Hucherson and Denman [290] discuss iliopectineal bursitis and report 2 cases. The psoas tendon passes over a thin portion of the capsule between the upper ends of the iliofemoral and pubocapsular ligaments, with a small subpsoas bursa averaging 5 by 7 cm. in length and 2 to 4 cm. in width intervening. This bursa is practically always present, and it has been found to communicate with the joint cavity in approximately 15 per cent of the cases. Early symptoms are pain, change in gait, flexion of the hip and knee, adduction and external rotation of the hip and protection against hyperextension. Fulness or swelling in the groin is a late finding. Pain is elicited by hyperextending, abducting or internally rotating the thigh. There is tenderness to pressure over an area about 2 cm. in diameter just below Poupart's ligament and lateral to the femoral artery. Hypertrophic changes in the hip are a predisposing factor to iliopectineal bursitis. The condition must be differentiated from cold abscess, perinephritic abscess pointing in the groin, femoral and inguinal hernia, varicosity of the saphenous vein, hydrocele of the cord and lymphadenopathy. Rest, heat and a hip spica with a window over the femoral triangle for the application of heat will shorten the period of recovery.

Ghormley and Flashman [291] discuss arthrokatadysis, better known as Otto pelvis, or intrapelvic protrusion of the acetabulum, and report 1 case. The patient was a 12 year old girl whose symptoms began three years previously. She walked with crutches, and there was practically no motion of her hips. She had an unusual amount of intrapelvic protrusion. She was treated by various methods, i. e., straight and lateral traction, a padded turnbuckle splint between the thighs with the ankles drawn together and long leg casts with a bar joining the ankles and a turnbuckle between the thighs. The final treatment consisted of the insertion of Kirschner wires through the upper end of the femurs and the application of a double spica cast to the hips, with an apparatus incorporated to permit lateral traction on the wires. When she was dismissed one year after admission to the hospital she was on crutches, but there was active flexion of 15 degrees in the left hip and of 30 degrees of the right, and there had been a gain in the intrapelvic diameter.

Longhi [292] discusses the anatomic pathogenesis and the clinical and roentgenographic features of ischiopubic osteochondritis. He describes two types, one with changes in enchondral ossification due to growth

290. Hucherson, D. C., and Denman, F. R.: Non-Infectious Iliopectineal Bursitis, Am. J. Surg. **72**:576-579 (Oct.) 1946.

291. Ghormley, R. K., and Flashman, F. L.: Arthrokatadysis: Report of Case, Proc. Staff Meet., Mayo Clin. **21**:108-112 (March 6) 1946.

292. Longhi, L.: Ischium-Ischiopubic Osteochondritis, Arch. di ortop. **57**: 119-145 (March) 1942.

disturbances and the other with changes in enchondral ossification due to local infection.

Françon [293] reviews the clinical features of an entity called the Debray-Milkman or the looser syndrome. The diagnosis is confirmed by roentgenologic study, which shows multiple symmetric pseudofractures. The condition leads to invalidism, progressive emaciation and cachexia. He states that a response may be expected in about two months after treatment with intravenous injections of 10 cc. of 10 per cent calcium gluconate and the administration of vitamin D.

Buchanan [294] found ankylosis bilaterally in a white cadaver; the patient was mentally defective and was 38 years of age at the time of death. He had been a bed patient for the last seven years of his life. There were extra-articular arches of bone located anterior to the joints, and on one side the bony arch extended from the region of the anterior inferior iliac spine to the anterior surface of the femur. Microscopic section showed the ankylosing factor to be true bone. The tendons of the iliopsoas and pectineus muscles were not involved. The iliofemoral ligaments could not be demonstrated, and it is probable that the ossification occurred in these ligaments. [Ed. Note (J. J. F.).—Roentgenograms of the hips appear to show ossification in the region of the iliopsoas muscles rather than in the iliofemoral ligament.]

Elizalde [295] reports 2 cases of obstetric dislocation of the hip associated with fracture of the femur. The condition was caused by forcible maneuvers during breech deliveries. The clinical picture is characterized by apparent disproportion in length of the infant's limbs after a difficult labor, and there is intense pain on motion of the injured limb. A swelling of the inguinal region of the thigh and the gluteal region occurs a few days later, with a browny induration and a slight elevation of the cutaneous temperature, and the limb is held in slight flexion and external rotation. The treatment consists of reduction by the Lorenz procedure as used for congenital dislocation of the hip. The hip is immobilized in a position of 135 degrees of flexion, 40 degrees of abduction and slight rotation. The results in both cases were good.

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293. Françon, F.: False Coxarthrias Due to Looser Syndrome (Formerly Maurice Debray-Milkman Syndrome), Rev. du rhum. **12**:181-183 (Aug.) 1945.

294. Buchanan, A. R.: Bilateral Extra-Articular Ankylosis of the Hip Joint, J. Bone & Joint Surg. **28**:31-384 (April) 1946.

295. Elizalde, E. A.: Obstetrical Dislocation of the Hip Associated with Fracture of the Femur, J. Bone & Joint Surg. **28**:838-841 (Oct.) 1946.

VII. CONDITIONS INVOLVING THE SHOULDER, NECK AND JAW

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Lesions of the Scalp.—Kelly [296] records 2 cases in which total avulsion of the scalp was treated by replacement, with successful results. He states that the requisite points for the accomplishment of this end are to keep the avulsed skin cool and moist and to prepare the replaced skin by meticulous removal of the subcutaneous tissues and fat with a razor or a sharp scalpel. It is felt that the use of cool isotonic sodium chloride solution over the entire exposed area as well as over the avulsed scalp increases the survival time of the living tissues. He further presents cases of avulsion of skin elsewhere, as from the index finger, the lower half of the patella and the second finger. The results were successful in all cases when the avulsed skin was denuded in the described manner before replacement. The literature concerning avulsions of the scalp (scalping) is completely reviewed by the author, and he suggests that the reported poor results are attributable to improper preparation of the avulsed tissue before its resuture in place.

[ED. NOTE.—The method described is a far cry from the previously employed technic of drilling the external cortex of the skull with multiple holes in persons who had been scalped by Indians. The literature on this method is most interesting; though healing was delayed over a long period for epithelization of the area from the sides, many excellent results accrued. The question arises as to whether multiple drilling and replacement of the denuded integument, actually representing a full thickness skin graft, would not be a safer procedure than replacement of such material on an intact external table of the skull.]

Facial Maxillary Injuries and Reconstruction.—The possibility of a demonstration of a temporomandibular hydrarthrosis preoperatively is presented by Bachman and Bershon.[297] They report a case and mention one other similar incident recorded in the literature.

296. Kelly, M. W.: Avulsion Injuries Including Two Cases of Avulsion of Scalp, Am. J. Surg. **72**:103-109 (July) 1946.

297. Bachman, A. L., and Bershon, A. L.: Hydrarthrosis: Roentgenographic Appearance of Temporomandibular Hydrarthrosis, Radiology **46**:251-257 (March) 1946.

An analysis of the movements of the jaw, both normal and abnormal, is presented by Burman and Sinberg.[298] They report a study based on the clinical examination of the temporomandibular joints of 105 patients, approximately half of whom were normal. The clinical manifestations, complaints and roentgenologic signs as compared with those in a large series of normal persons are described. The problem of interposed meniscus is considered under three headings, namely, the untreated joints recovering spontaneously, the untreated joints in which secondary arthritic changes develop and the fixed joints relieved only by surgical intervention. Differentiation is made between the dislocation associated with laceration of the meniscus which is irreducible and dislocation which can be treated with manipulation. The review of pathologic lesions of the temporomandibular joint is extensive. Correlation of all findings with actual pathologic changes is accomplished.

[ED. NOTE.—This paper represents a basic contribution which should be read and studied.]

Blocker and Weiss in two articles take up facial maxillary injuries. The first[299] records the increased incidence of this type of injury in World War II. The problems are presented in orderly fashion and point out the fact that patients must be treated with respect to their general condition as well as to the local injury. The uses of various types of graft and their manner of application are illustrated. Procedures illustrated include the use of split grafts, full thickness grafts and grafts of derma and fat and the use of cartilage and bone as well as of delayed pedicle grafts. The second paper[300] supplements the first to a considerable degree and more specifically applies to the grafting of bony defects of the jaw. A detailed outline of operative technic and postoperative care is given. Defects from 3 to 12 cm. in length in the lower jaw are reported successfully bridged. The lengthy preparations, with removal of the sequestra and fragments of teeth, and the subsidence of infection are emphasized. The use of cancellous grafts from the ilium is advocated. The application of 43 grafts without mishap is reported. An extensive bibliography accompanies the article. In a third paper[301] Blocker reviews the data in his previous paper and again presents his method of operative iliac grafting of defects in the

298. Burman, M., and Sinberg, S. E.: Condylar Movement in Study of Internal Derangement of Temporomandibular Joint, J. Bone & Joint Surg. **28**:351-373 (April) 1946.

299. Blocker, T. G., Jr., and Weiss, L. R.: Maxillofacial Injuries, J. Indiana M. A. **39**:60-63 (Feb.) 1946.

300. Blocker, T. G., Jr., and Weiss, L. R.: Use of Cancellous Bone in Repair of Defects About Jaws, Ann. Surg. **123**:622-638 (April) 1946.

301. Blocker, T. G., Jr.: Cancellous Bone Grafts to the Jaw, Surg., Gynec. & Obst. **84**:553-561 (April) 1947.

mandible. Once more he emphasizes the necessity of proper preparation of the tissues before operation is attempted to secure osteogenic repair.

[ED. NOTE.—These three papers contain material providing an excellent outline for those interested in the repair of defects in the mandible. The difficulties ecountered are emphasized by the authors' specific warning as to the preparation of the bone graft site and the insistence that this must be satisfactory before the grafts are attempted. Their stand on the use of cancellous bone for graft material seems excellent.]

Leach and others [302] report data from 1,148 cases of facial maxillary injury in an evacuation hospital where the incidence of such injuries was 7.1 per cent. Since they are rather specific in their article as to the best manner of treatment, including immediate care and other subsequent measures in the preparation for definitive surgical procedures at a later date, this work represents an outline of the care of such injuries whether they be in persons of military or civilian status. They include interesting tables on causative wounding agents, the type of wound and the number of associated injuries of the face seen. Definite recommendations for specific treatment of wounds of the various parts, such as the eyes, eyelids, external ear, lip, tongue, mouth and floor of the mouth, are included. Methods of treatment of the various bony structures, such as the mandible, zygomatic arch and mastoid process, are concisely stated. Problems arising out of laceration of the external carotid artery, the lingual artery, the internal jugular vein and the common carotid artery are reviewed. The comparative efficiency of anesthetic methods used and the indications for each are included. Types of tracheotomies and indications for them are discussed. The authors conclude that primary closure of the neck for facial injuries is the treatment of choice.

[ED. NOTE.—This paper represents a rather full discussion of the subject and includes much statistical data.]

Articles on ankylosis of the jaw and on procedures to relieve it include two by Eggers. In his first article [303] in 1941 he recommended the use of fascia lata interposed between resected bony surfaces. In his later article [304] in 1946 he advised the implantation of double thickness

302. Leech, C. H.; Drum, B. C., and Osterhagen, H. F.: Management of Plastic Maxillofacial Wounds in Evacuation Hospital, Surg., Gynec. & Obst. **83**: 462-473 (Oct.) 1946.

303. Eggers, G. W. N.: Ankylosis of Mandible, South. Surgeon **10**:1-7 (Jan.) 1941.

304. Eggers, G. W. N.: Arthroplasty of Temporomandibular Joint in Children with Interposition of Tantalum Foil: Preliminary Report, J. Bone & Joint Surg. **28**:603-606 (July) 1946.

tantalum foil on either side of the resected previously ankylosed area. This article is essentially a report on a 4 year old child on whom arthroplasty of the temporomandibular joint was carried out by the latter method. He includes a follow-up report on 3 previous cases, the longest period of follow-up being two years and ten months. Results are reported as satisfactory in all cases.

Dingman [305] presents a valuable article in which the pathologic process in ankylosis of the temporomandibular joint is concisely stated. Operative procedure for treatment of the ankylosis is given in detail. He emphasizes the importance of not inserting any material into the operative defect. Wide excision of the condylar region of the mandible under local anesthesia is stated as preferable, and he feels that it is unwise to perform this bilaterally at a single sitting.

Brown and Peterson [306] present a paper describing a similar technic without the interposition of tissue after removal of the ankylosis.

[ED. NOTE.—It has been my experience that satisfactory results are secured by wide resection of bone to remove the ankylosis in the temporomandibular articulation. There appears to be no advantage in the introduction of extraneous substance, particularly since most authors agree that débridement of the wound should be done if such material exists at the time the ankylosis is removed.]

Lesions Involving the Cervical Region.—Adson, Young and Ghormley [307] present a review of the etiologic factors which have been considered in spasmodic torticollis, with a detailed discourse on the type of operation which they now feel is necessary in severe cases in which the condition has not responded to conservative measures. When several muscles on both sides of the neck are affected, a major procedure is recommended by the authors. This consists of bilateral section of the spinal accessory nerve and bilateral rhizotomy of the motor roots of the three upper cervical nerves. In some cases in which this procedure has been employed the spinal accessory nerves have been divided in the cervical region prior to laminectomy and rhizotomy. It is stated that this extensive procedure has given some satisfactory results, although in certain cases subluxation, with anterior curvature of the upper cervical vertebrae, has resulted. In such instances the patient's head falls forward and the mandible is pressed

305. Dingman, R. O.: Ankylosis of Temporomandibular Joint, Am. J. Orthodontics (Oral Surg.) **32**:120-125 (Feb.) 1946.

306. Brown, J. B., and Peterson, L. W.: Ankylosis and Trismus Resulting from War Wounds Involving Coronoid Region of Mandible: Three Cases, J. Oral Surg. **4**:258-266 (July) 1946.

307. Adson, A. W.; Young, H. H., and Ghormley, R. K.: Spasmodic Torticollis: Severe Organic Type Treated by Combined Operation, Rhizotomy and Fusion, J. Bone & Joint Surg. **28**:299-308 (April) 1946.

into the neck in such a manner as to interfere with breathing, swallowing and speaking. This deformity has been partially overcome by the application of a Thomas collar or of some similar support. Because of this complication, the authors have devised an operative procedure in which a bone graft from the ilium is placed from the occiput over the upper cervical region of the spine. The procedure then becomes one of combined nerve division and spinal fusion. It is appreciated by the authors that this is a major operation and is only to be employed when the patient is actually incapacitated as a result of spasmodic torticollis.

A review of the cervical rib syndrome by McGowan [308] scans the literature on the mechanism of the symptomatology associated with this condition. In the differentiation from the scalenus anticus syndrome he includes the conditions of (1) supraspinatus injury, (2) subarachnoid tumor, (3) cervicodorsal sympathalgia, (4) Raynaud's disease, (5) cervical arthritis, (6) brachial plexus neuritis and (7) slipped intervertebral disk. He reviews what he considers to be the mechanics at work when a cervical rib is present along with symptoms. He divides the symptoms resulting from such a condition into neurologic and vascular. The neurologic symptoms include pain of a sharp, lancinating nature located in the scapular region, with radiation down the arm or at times up the side of the neck. Pain is worse at the end of the day, and in women it is aggravated by certain types of work depressing the shoulder. Anesthesia, paresthesia, burning, tingling or numbness may be present. The circulatory symptoms include blanching, tingling or coldness. These occur during the carrying of certain objects or the assumption of certain positions for long intervals such as those assumed while sleeping. When the symptoms described are present, McGowan believes the presence of a cervical rib as demonstrated in the roentgenogram, to be responsible. Surgical procedures for both division of the scalenus anticus muscle and removal of cervical ribs are presented in detail. He warns of the danger of injury to the brachial plexus, subclavian artery, phrenic nerve and cervical pleura as well as to the thoracic duct on the left. He mentions the possibility of an accessory thoracic duct on the right and presents 4 case reports in detail. In these reports he differentiates between the findings in cases of occlusion of the subclavian artery and those in cases of vasospasm of the artery following sympathetic irritation. By keeping these in mind, he states, cases may be divided into those in which relief can be obtained successfully by the performance of a simple myotomy of the scalenus anticus and those in which rongeuring away of a portion of the cervical rib is necessary when such a rib causes compression

308. McGowan, J. M.: Cervical Rib: Role of Clavicle in Occlusion of Subclavian Artery, Ann. Surg. **124**:71-89 (July) 1946.

of the subclavian artery against the clavicle. A report on 3 of 9 patients subjected to combined scaleniotomy and partial resection of the cervical rib is given. All were followed; the results were excellent, with no deaths or sequelae.

Spurling and Scoville [309] thoroughly review the salient features of diagnosis of ruptured cervical intervertebral disk. They make a plea that pain in the arm and shoulder be considered as possible basic symptoms for the diagnosis of this condition. It is suggested that neuritis in the presence of the scalenus anticus syndrome is too often thought of as the cause of symptomatology when in fact a ruptured fifth or sixth cervical disk may be present. It is felt that accurate localization of the lesion on clinical findings alone is usually possible. This they believe can be accurately verified by pantopaque myelography. They state that although conservative treatment may relieve symptoms, operative removal of the lesion is justified when conservative measures fail on the basis that it is a simple, safe procedure and the results are excellent. Statistical data on 12 patients are presented.

[Ed. Note.—This article should be read by those interested in operating for cervical disks. While removal of most cervical disks is not too intricate a procedure and the results are excellent in the hands of those thoroughly conversant with surgery of the cervical spine, the procedure may prove difficult, and disasters when they occur are of considerable magnitude.]

Whiteleather, Semmes and Murphey [310] present a brief résumé of the clinical findings when typical herniation of a cervical intervertebral disk occurs. Abnormalities which may be present in roentgenograms of the cervical region of the spine are shown. It is stated that a loss or a reversal of normal cervical lordosis, either complete or partial, with narrowing of the intervertebral space, calcified particles of disks and osteophytes or proliferative spurs projecting into the foramen and from the anterior margins of the body, along with alterations in the size and shape of the foramens, increased mobility of the vertebral body and defects in the pantopaque myelogram may not be pathognomonic but are highly suggestive of injury to the disk. They suggest that when correlated with the history, symptomatology and neurologic findings, they are strongly confirmatory. The fact is stressed that when there is recent or acute protrusion no roentgenologic abnormalities

309. Spurling, R. G., and Scoville, W. B.: Lateral Rupture of Cervical Intervertebral Discs: Common Cause of Shoulder and Arm Pain, Surg., Gynec. & Obst. **78**:350-358 (April) 1944.

310. Whiteleather, J. E.; Semmes, R. E., and Murphey, F.: Roentgenographic Signs of Herniation of Cervical Intervertebral Disk, Radiology **46**:213-219 (March) 1946.

need be present. They commend the routine use of oblique roentgenograms of the cervical region of the spine. As can be seen, their paper deals with the various abnormalities which the roentgenologist feels may be helpful in making a diagnosis of herniation of the intervertebral disk.

[ED. NOTE.—It would seem that a clearer picture of the herniated cervical disk causing pressure on the nerve roots was provided by the pattern of the complaints and the clinical picture than by the roentgenologic findings. This paper's importance lies in the insistence on a satisfactory roentgenologic examination of the cervical region of the spine and on enumeration of changes to be found therein. Such changes have been found to be confusing and not to correlate too well with the location of the herniated disk as found at operation.]

Lesions of the Shoulder.—A comparative anatomic study of the dissected brachial plexus, pectoral muscles, coracoid area and structures in the upper extremity of the gorilla as contrasted with those in man is reported by Kaplan.[311] He brings out the variations in anastomosis of the median and ulnar nerves in the forearm of man, with a clarification of obscure points in the interpretation of the unexplained absence of paralysis of the intrinsic muscles of the hand in cases of injury high in the ulnar nerve. He emphasizes the possible change in position of the posterior interosseous nerve in the upper part of the forearm. In another article [312] he describes the occasional presence of Langer's muscle of the axilla, first noted in 1846 and described under the name of *"Aschselbogen."* It is a flat muscle originating from the tendon of insertion of the latissimus dorsi and inserted into the reflected portion of the tendon of the pectoralis major near the bicipital groove.

Soule [313] reports on 18 patients with dislocation of the acromioclavicular articulation, in 14 of whom there subsequently developed osseous deposits in the region of the coracoclavicular ligament. Anatomic consideration of ligamentous structures about the acromioclavicular articulation are briefly considered. The cases are presented in some detail as to the mode of injury, method of treatment and eventual roentgen findings. The author concludes that post-traumatic ossification of the area of the coracoclavicular ligament is a common sequela of dislocation of this joint and more commonly seen when such dislocations are complete. Calcifications are reported to appear in from

311. Kaplan, E. B.: Notes on Upper Extremity of Gorilla: Clinical Application, Bull. Hosp. Joint Dis. **7**:129-136 (Oct.) 1946.

312. Kaplan, E. B.: Surgical Anatomy: Langer's Muscle of Axilla, Bull. Hosp. Joint Dis. **6**:78-79 (Oct.) 1945.

313. Soule, A. B., Jr.: Ossification of Coracoclavicular Ligament Following Dislocation of Acromioclavicular Articulation, Am. J. Roentgenol. **56**:607-615 (Nov.) 1946.

three to six weeks after injury and to become complete in about eight to ten weeks. It is stated that if ossification is not obtained within six weeks of injury it will probably not appear at a later date. The author speculates that ossification of the area of the coracoclavicular ligament may be of some aid in restoring stability to the damaged region.

A review of the differential diagnosis in cases of painful lesions of the shoulder is made by McBride.[314] The classification includes (1) lesions in which pain is referred to the cervical region, (2) rheumatic disorders, (3) injuries to the capsule and the tendon and (4) injuries to bones and joints. An extensive subclassification is given. There is a discussion of the differential diagnosis of these conditions. A short discussion of various modes of treatment is included. The paper emphasizes the fact that a thorough knowledge of all conditions leading to pain in the shoulder and disability is imperative if responsibility for treatment is to be undertaken.

Thirty-one cases in which operative correction was done for recurrent dislocation of the shoulder are discussed by Myers.[315] He emphasizes the importance of the pathologic changes which occur in the capsule, the joint cavity and the posterolateral section of the head of the humerus. A detailed method of capsulorrhaphy is presented. Results are evaluated and reviewed in terms of the type of dislocation, the total treatment given and the pathologic changes present. All patients were reported to present a detachment of the capsule from the rim at the site of the defect. Seventy-three per cent were found to have a fracture of the glenoidal labrum. Half of the patients had osteochondritic or degenerative changes in the humeral head. It is stated that intra-articular damage is not caused by the capsulorrhaphy done. The longest period of follow-up was eighteen months.

A series of fourteen operations performed on 13 patients for repair of recurrent dislocations of the shoulder by a new technic is given by Crosby.[316] The procedure consists essentially of anchoring of the tendon of the long head of the biceps in the bicipital groove. Recurrence was recorded in 4 cases. A second operation, consisting of fascia lata reefing, was performed in these cases. Thereafter a third operative procedure was used in 32 cases consisting of transplantation of the long head of the biceps from its supraglenoid tubercle origin to the

314. McBride, E. D.: Injuries to Shoulder, New Orleans M. & S. J. **98**:533-541 (June) 1946.

315. Myers, O. R.: Experience with Capsulorrhaphy for Recurrent Dislocation, J. Bone & Joint Surg. **28**:253-261 (April) 1946.

316. Crosby, E. H.: Surgical Procedure for Repair of Recurrent Dislocation of Shoulder Joint: Preliminary Report, J. Bone & Joint Surg. **28**:809-812 (Oct.) 1946.

acromion process. Only 8 cases have been followed for more than one year. One recurrence of dislocation took place.

[ED. NOTE.—In both of the series mentioned a longer postoperative period of follow-up would seem indicated. Discussion of this matter should not be closed without mention of the efficacy of procedures which employ transplantation of the scapularis tendon.]

McLaughlin deals with the musculotendinous cuff of the shoulder in three papers. In his first paper [317] he speaks of the exposure and treatment of tears with retraction. He reemphasizes the necessity for care in the performance of deltoid dissection to avoid damage to axillary nerve branches infiltrating the muscle. Osteotomy of the acromion process is advocated, and he reports that the outer fragment is discarded and the remaining stump beveled and reshaped without ill effect. He reports that good bony union has occurred in all cases, whether fixation was used or not, when the fragment has not been discharged. He discusses the treatment of incomplete and complete ruptures of the tendinous cuffs. Under the heading of complete rupture he classifies transverse rupture, longitudinal splits, tears with retraction and massive avulsion of the cuff. The operative procedure of choice is discussed at considerable length. In his opinion, the transacromial approach is useful for surgical procedures involving the cuff, capsule, humeral head, long biceps tendon and intra-articular cavity of the shoulder. He believes benefit is gained by excising and discarding the outer fragment of the divided acromion. He states that retracted tears of the musculotendinous cuff can be repaired according to this method. It is stated that massive avulsion of the cuff per se does not warrant fusion of the shoulder. A report of 32 cases is summarized in tabular form, including cases of uncomplicated tears of the musculotendinous cuff. A report of 8 cases of what was stated as massive avulsion of the cuff is given. McLaughlin agrees with Codman that the formation of a typical crescentic or triangular hiatus type of defect eventually occurs if repair is not done. In his second paper [318] he treats of the differential diagnosis of lesions of the musculotendinous cuff. Requirements for such diagnosis include a detailed history, compatible subjective symptoms, the presence of functional derangement of a typical nature and local signs of damage together with elimination of any other condition. He describes the anatomy of the tendinous cuff and the action of its component parts. Dislocations of the shoulder, with fractures of the greater tuberosity,

317. McLaughlin, H. L.: Lesions of Musculotendinous Cuff of Shoulder: Exposure and Treatment of Tears with Retraction, J. Bone & Joint Surg. **26**: 31-51 (Jan.) 1944.

318. McLaughlin, H. L.: Lesions of Musculotendinous Cuff of Shoulder: Differential Diagnosis of Rupture, J. A. M. A. **128**:563-568 (June 23) 1945.

are reviewed and divided into three types. In his third paper [319] he records the pathologic process, the course and the treatment of calcific deposits about the shoulder. He believes the origin of such deposits to be the end result of a degenerative change following trauma or overuse of the arm. Secondary rupture of degenerative fibers may occur. The mechanism of the production of pain consists in inflammation centered in the vascular peritendinous tissues and fairly well restricted to them. These include the short rotator tendons of the shoulder and the synovial floor of the subdeltoid bursa. Therefore inflammation resulting from irritation by calcific deposits may produce the clinical syndrome of tenosynovitis and subdeltoid bursitis of the shoulder. The variation of the symptomatology produced by lesions appearing identical in roentgenograms is recounted. As regards therapy, it is stated that chronic lesions may warrant operative removal of the deposits as the only certain and speedy method of obtaining permanent relief. For acute conditions, the treatment of choice is stated to consist of puncture of the tense deposits and aspiration of their contents by needle under local anesthesia.

[ED. NOTE.—The first two of these papers are recommended in their entirety. While I would not agree that transection or removal of a portion of the acromion process should be done, they are stimulating to one interested in lesions of the shoulder cuff.]

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319. McLaughlin, H. L.: Lesions of Musculotendinous Cuff of Shoulder: Observations on Pathology, Course and Treatment of Calcific Deposits, Ann. Surg. **124**:354-362 (Aug.) 1946.

VIII. CONGENITAL DEFORMITIES

Prepared by

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SINCE 1941 I have begun the section on congenital deformities with an article by Josef Warkany. I will follow the now established custom and do the same this year.

He says [320] that congenital defects are deviations from the normal which are present at birth. Such defects may be morphologic or functional and may be hereditary or acquired, but they are always determined before birth. The fact that mammalian congenital defects arise in the maternal uterus, seemingly uninfluenced by visible environmental factors, has kept their origin obscure and their prevention beyond human influence. Superstition and confusion have been and still are prevalent in the speculations on the origin of congenital defects, more so than in any other field of human pathology.

We must look to embryologic morphology and embryologic chemistry for an understanding of prenatal development. A continuous chain of physicochemical reactions regulates the development of the unborn child from the first cell, the zygote, to the complex multicellular organism of the newborn. Any interruption of these reactions results in damage to the embryo or fetus. The time of the injury is of great importance, since the defects are determined to a certain extent by the developmental state of the affected organism. In general the damage is more serious the earlier the embryo is injured. Within the first ten weeks of gestation the unicellular ovum develops into an embryo which has the principal features of a human being. All the organs and organ systems are essentially determined and recognizable in the third month. In this first period of organogenesis, the embryo is extremely vulnerable and injuries result in severe malformations. The second period of gestation, which lasts from the third month to birth, is essentially devoted to growth. Adverse factors acting in this period may cause disease or retarded development.

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320. Warkany, J.: Some Factors in the Etiology of Congenital Malformations, Am. J. Ment. Deficiency **50**:231-241 (Oct.) 1945.

There can be no doubt that many congenital malformations are genetically determined. By this statement it is meant that a defective gene or an unfavorable combination of genes present in the zygote determines a developmental disturbance which results in congenital malformations.

Environmental interference with prenatal development may also lead to congenital malformations. Infectious, actinic, toxic and nutritional factors can interfere with normal embryonic development and result in congenital defects.

Among the infectious agents leading to congenital malformations, the virus of rubella should be mentioned first. Prenatal infection with the protozoan toxoplasma results in a congenital syndrome of internal hydrocephalus or microcephalus, chorioretinitis and calcifications of the brain. The effects of prenatal syphilis are well known.

Exposure of the embryo to large doses of roentgen rays may result in congenital malformations. A number of cases are on record which show that inadvertent irradiation of the uterus of a pregnant woman may lead to microcephaly, mental deficiency and malformations of the eye and the extremities in the child. The rpentgen ray doses employed as well as the developmental stage of the embryo determine the type of malformation.

It is possible and even probable that toxic factors can induce congenital malformations. It has been asserted that alcohol, lead, various contraceptives, parental tuberculosis and syphilis may adversely influence prenatal development and result in congenital malformations.

[Ed. Note (J. H. Kite).—See the "Progress in Orthopedic Surgery" for the four previous years for reports by Warkany and his co-workers. They have shown that many skeletal abnormalities have followed the feeding of female rats a diet deficient in riboflavin. The newborn rats have shown a shortening of the lower jaw, shortening or absence of the tibia, fibula, radius and ulna, fusion of ribs and syndactylism of various degrees. When riboflavin, or liver which is a good source of riboflavin, is added to the deficient diet, only normal young are born.]

Syndactylism resulting from genetic factors has occurred in mice. Syndactylism also occurs in the young of mothers fed a diet deficient in riboflavin and in the young of mothers exposed to roentgen rays during pregnancy. The first type of syndactylism is hereditary, the latter types are not.

An abnormal character may be due to an abnormal gene. But the same abnormal character may appear in the presence of a normal gene if the chain of developmental processes is interrupted by injurious environmental factors.

Eugenic measures must take into account not only genetic factors but also the environmental conditions which can influence the development of the unborn child.

The question has been raised whether environmental factors operating for the first time after the fertilization of the ovum can cause congenital abnormalities.

Conte, McCammon and Christie [321] say that many theories have been suggested to explain the causation of congenital malformations. A number of observations have been made to support the contention that the environment of the ovum after fertilization can be influenced sufficiently to modify its growth and development. It is, nevertheless, generally accepted that most congenital malformations are due to intrinsic or inherited factors. The evidence that defective germ plasm prior to fertilization of the ovum is responsible for congenital malformations was reviewed by Murphy. He could find no evidence to suggest that malformations result from environmental factors which operate for the first time after fertilization has taken place.

Recently, however, it has been suggested that there is a relationship between certain acute infectious diseases suffered by the mother early in her pregnancy and the development of anomalies in the offspring. Gregg, in 1941, was the first to suggest this in his report of 78 cases of congenital anomalies in children whose mothers suffered from a virus infection early in their pregnancies. Swan reported 43 similar cases.[321a]

One hundred and thirty-four cases have been reported in the literature in which maternal rubella in pregnancy was followed by congenital abnormalities. In all but 3 of these cases the rubella occurred in the first trimester of pregnancy. Congenital cataracts, congenital heart disease and definite mental retardation of the child usually resulted.

It is difficult to evaluate the significance of these reported cases because it is not known how often virus infections occur without congenital malformations or how often malformations occur without virus infections. In other words, there are no controls for the reported cases.

Five additional cases of maternal rubella and congenital abnormalities of the offspring were reported from Vanderbilt University School of Medicine. In 4 of these the maternal rubella occurred in the first trimester of pregnancy. The 4 infants had congenital malformations of the heart and mental deficiency, and 3 had congenital cataracts. In

321. Conte, W. R.; McCammon, C. S., and Christie, A.: Congenital Defects Following Maternal Rubella, Am. J. Dis. Child. **70**:301-306 (Nov.-Dec.)) 1945.

321a. Swan, C.; Tostevin, A. L.; Mayo, H., and Black, G. H. B.: Further Observations on Congenital Defects in Infants Following Infectious Diseases During Pregnancy, with Special Reference to Rubella, M. J. Australia **1**:409 (May 6) 1944.

the fifth case the mother had rubella at seven months of gestation. Congenital cataracts and cerebral aplasia were noted in the infant.

Maternal rubella was noted in 4.2 per cent of the cases of congenital abnormalities surveyed. This exceeds by at least ten times the actual case rate of maternal rubella for the child-bearing age group in the population at large.

They conclude that these associations furnish additional evidence that environmental factors operating for the first time after fertilization of an ovum can cause congenital abnormalities.

Prendergast [322] made a review of the reported cases of congenital defects in children born of mothers who had rubella during the first three months of pregnancy. This was a California survey.

Gregg expressed the opinion that the majority of cases of rubella concerned in his study occurred during a so-called epidemic in 1940 which affected rather widespread areas in Australia. The attacks of rubella were rather severe in most cases. In California the rubella occurred in a mild, almost subclinical form. If the virus in the cases occurring in this country is similar to the virus in cases in Australia, it would seem that it must be of an attenuated nature.

In the fall of 1944 a survey was made among some of the ophthalmologists, pediatricians and obstetricians in California to obtain an idea of the incidence of congenital anomalies among children whose mothers had had rubella during the first three months of pregnancy.

A total of 80 cases of congenital cataract and 10 cases of other ocular defects, 32 cases of cardiac defects and 10 cases of other congenital anomalies were reported.

Because the greater number of cases to date has been reported from the western part of the United States, one wonders whether such congenital defects are more prevalent in this part of the country or whether, like the epidemic of shipyard conjunctivitis of several years ago which started in Hawaii and spread to the Pacific coast and thence to the rest of the United States, this condition has spread to the Pacific coast from Australia, where it was first reported, and is now making its way across the country. Further surveys will be of interest from this point of view.

Fox and Bortin [323] approached the problem of malformations following rubella in early months of pregnancy by studying the patients who had it. They say that the investigators had failed to cite the total number of women who had rubella during pregnancy and gave birth to children with no congenital defects. The entire subject must be

322. Prendergast, J. J.: Congenital Cataract and Other Anomalies Following Rubella in Mother During Pregnancy, Arch. Ophth. **35**:39-41 (Jan.) 1946.

323. Fox, M. J., and Bortin, M. M.: Rubella in Pregnancy Causing Malformations in Newborn, J. A. M. A. **130**:568-569 (March 2) 1946.

interpreted from the public health point of view. They gave the following as their conclusions:

1. Rubella has occurred in the city of Milwaukee in epidemic proportions approximately every ten years.

2. In a survey of the period 1942, 1943 and 1944, 22,226 cases of rubella were reported, of which 152 involving married women were investigated. Eleven of the women were pregnant at the time they had rubella.

3. Of the 11 pregnant women who had rubella, 5 had the disease during the first two months, 4 during the second to the fourth month, 1 in the seventh month and 1 in the ninth month.

4. One stillbirth occurred among the 11 cases; 1 woman had twins, both normal, and 1 woman gave birth to a child with congenital cataracts at the end of a normal pregnancy and delivered a normal child at the end of a pregnancy during which she had rubella in the second month.

5. The records do not justify consideration of termination of pregnancy because of rubella.

6. The occurrence of congenital malformations in virus disease in pregnant women is a subject deserving of further careful investigation.

Parsons,[324] from Birmingham, England, reviews the literature and concludes that instances of rubella should be reported in England and Wales, especially when it occurs in married women.

In June 1946 he gave the Fifth Blackader Lecture before the Canadian Medical Association on "The Effect of Ante-Natal conditions on the New-born Child.[325] He stresses the need for more study of "ante-natal paediatrics." Most of this lecture is of pediatric interest. He discusses the effect of maternal diet, the nutritional state of the mother and the health of the mother as it affects the newborn child. The effects of rubella are again reviewed. Two paragraphs of this lecture are quoted:

> One of the earliest enquiries about the effect of ante-natal conditions on the new-born with which I am familiar was the question put to our Lord by his disciples; "Master who did sin, this man or his parents that he was born blind?" You remember the reply, "Neither hath this man sinned nor his parents, but that the works of God might be made manifest in him." Is it fanciful to think that therein lies an explanation of the existence of disease and that the research worker is a fellow worker with God?
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> It is interesting to note that Shakespeare (A Midsummer Night's Dream, Act. V, Sec. 2) refers to some of the deformities now associated with German

324. Parsons, L. G.: Maternal Rubella as a Cause of Congenital Defects, Brit. M. Bull. **4**:193-196, 1946.

325. Parsons, L. G.: The Effect of Ante-Natal Conditions on the New-Born Child, Canad. M. A. J. **55**:327-336 (Oct.) 1946.

measles but attributed them to "the foul fiend Flibbertigibbet," "who gives the web and pin, squints the eye and makes the hare lip." "Web and pin," according to Goldbloom, our authority on Shakespearean paediatrics, probably refers to cataract or a corneal scar. A cynic (Vertue) has said recently that "science has done nothing about Flibbertigibbet unless you count the suggestion that one of his other names is German measles."

Davis, a senior at the Medical College of the State of South Carolina, was awarded a prize for a paper on "Congenital Malformations following Rubella in the Mother." This is a good review of the literature, with a summary of the conclusions of the various authors.

Wilson and Brown [326] report on 2 patients with fracture of the atlas and with congenital anomalies who were admitted to the hospital within ten days. Clinically, these anomalies are discovered only rarely and are seldom a cause of confusion in the diagnosis of fracture. They mention the work of Jefferson, who did much to dispel the belief that fractures of the atlas carry a high mortality rate and that they are extremely rare. He also pointed out that they usually result from force exerted on the top of the head with the spinal column fixed in the neutral position, causing a bursting fracture of the atlas ring. This is commonly of the posterior arch through the groove for the vertebral artery.

Ivie [327] reports a white soldier who injured his neck while wrestling. He suffered immediate weakness of the extremities but no loss of sensation. After lying quietly for half an hour, he gradually regained strength in the extremities but noticed a tingling sensation in the fingers and toes, more severe on the left side. Roentgen examination of the cervical region of the spine showed a partial dislocation of the atlas on the axis, anteriorly and laterally. The odontoid process of the second cervical vertebra was absent. The dislocation was reduced by traction of the head by means of Crutchfield tongs applied to the skull. The patient was comfortable in traction, and symptoms of tingling of the fingers and toes and weakness of the extremities disappeared. If fusion of the cervical region of the spine is not done, the patient should be carefully informed of the potential danger of his condition. There is always the possibility of a recurrence and perhaps of serious damage to the cord.

Gilmore and others [328] report 2 cases of spinal anomaly which could not be demonstrated by the conventional methods but which could be

326. Wilson, J. W., and Brown, N. M.: Congenital Anomaly and Fracture of the Atlas: Two Cases, Canad. M. A. J. **55**:52-53 (July) 1946.

327. Ivie, J. M.: Congenital Absence of the Odontoid Process, Radiology **46**: 268-269 (March) 1946.

328. Gilmore, J. H.; Stauffer, R. C., and Jacobs, L. G.: Two Cases of Spinal Anomaly, Best Demonstrated by Laminagraphy, Radiology **46**:515-517 (May) 1946.

outlined clearly by laminagraphic studies. They found a hemivertebra in 0.5 per cent of examinations of the cervical regions of the spine, 0.2 per cent of examinations of the thoracic region and 0.05 per cent of examinations of the lumbar region. One case involved a soldier who was struck on the back of his neck while boxing. He experienced immediate pain and gradual increasing tenderness of the cervical muscles, especially on the left, with some limitation of motion. The head and neck were held rigid as a protective mechanism. There was no radiating pain. Laminagraphic study showed an assimilation of the atlas in the occiput, with a supernumerary hemiatlas on the left. Bed rest and leather traction for fourteen days led to relief of symptoms.

Schachter [329] gives a description of two cases of hypertelorism (Greig). The first concerns a child of 5 and represents the pure type. The second involves a girl of 13 who had in addition a one-sided harelip. Both patients were mentally deficient and had relaxed joints. He gives a discussion of symptomatology and diagnosis.

The annual review of the Klippel-Feil syndrome was made this year by Erskine, of England.[330] He reviews the literature from the time the first case was reported by Klippel and Feil in 1912 to the present time and reports 1 case.

The three characteristic clinical features of the syndrome are shortness of the neck, limitation of movement of the head and lowering of the hair line.

Postmortem studies in cases of the Klippel-Feil syndrome are rare. The descriptions are usually limited to the osseous deformity. The essential features of the cervical deformity are synostosis of two or more cervical vertebrae and flattening and widening of the vertebral bodies.

Other abnormalities occur, some of which depend on the primary cervical lesion, such as torticollis, facial asymmetry, lowered nipple line, kyphosis and thoracic scoliosis, the last occasionally due to a hemivertebra.

The consensus regarding the cause of the Klippel-Feil syndrome is that it is a disorder of segmentation. It has been stated that the Klippel-Feil syndrome is not hereditary or familial; yet there are a number of cases reported in which it occurred in parents and children. The incidence is equal in males and females.

The most constant features are synostosis, flattening of the vertebrae, narrowing or obliteration of the intervertebral disks, shortening of the cervical region of the spine and spina bifida. In at least some cases it

329. Schachter, M.: Deux observations d'hypertélorisme de Greig, Ann. pædiat. **167**:199-206, 1946.

330. Erskine, C. A.: An Analysis of the Klippel-Feil Syndrome, Arch. Path. **41**:269-281 (March) 1946.

appears that the characteristically lowered hair line is due to the same type of hirsutism as that found in other regions in spina bifida occulta. It is doubtful if reduction in the number of vertebrae is an essential part of the disorder.

There is evidence that the anomaly has a genetic basis.

Soule [331] made a survey of all case reports and articles on mutational or cleidocranial dysostosis published from January 1929 through March 1944. He reported 6 additional cases. Mutational dysostosis is a condition, frequently transmitted by parents to offspring, which is characterized by multiple, variable developmental skeletal anomalies. The more prominent and frequent of these anomalies are aplasia of the clavicles, delay in closure of fontanelles and cranial sutures, brachycephalia, prognathism, irregularities in dentition and structural abnormalities in the skull bones, vertebrae, sacrum, pelvis, femurs, scapulas, metacarpals, metatarsals and phalanges.

The cardinal features of the syndrome are: (1) a varying degree of aplasia of the clavicles; (2) overdevelopment of the transverse diameter of the cranium coincident with delay in ossification of the fontanelles, and (3) hereditary transmission.

The term "cleidocranial dysostosis" was applied to this condition by all writers until 1936, when Rhinehart called attention to its mutational character and to the variety and inconstancy of findings and proposed the name "mutational dysostosis" as more rational and descriptive.

In cases in which there has been a hereditary background, transmission has been by both male and female members of the family to a nearly equal degree. In many instances the disease has appeared in two successive generations and has been lost in the following generation. In eight families the disease appeared in three successive generations, in four families it appeared in four successive generations and in one family it appeared in five successive generations. No authentic instance could be found in which the disease appeared in one generation, skipped one or more generations and then appeared in a subsequent generation.

The etiology of the disease is unknown, but it is unquestionably associated with a defect in the parental germ plasm. There is a faulty anlage in the system of membranous bones, the skull bones and clavicles, which is also present occasionally in the bones of chondral origin.

Defects in the clavicles are among the commonest lesions found in mutational dysostosis and may vary from a small defect in one clavicle to complete absence of both bones. Usually small, bony stumps are present

331. Soule, A. B., Jr.: Mutational Dysostosis (Cleidocranial Dysostosis), J. Bone & Joint Surg. **28**:81-102 (Jan.) 1946.

mesially, which articulate with the sternum and to which the sternomastoid and pectoralis major muscles are attached. In about 10 per cent of all reported cases the clavicles are entirely absent.

The appearance of most of the patients is strikingly similar; in spite of racial differences, there is almost a family resemblance. The most troublesome defects are the dental abnormalities, with their attendant complications. If the arches of the feet are poorly developed or if there are such changes as genu valgum, coxa vara or coxa valga, difficulties in gait and posture may be experienced. If the pelvis is contracted, normal labor may be impossible. If spinal anomalies are present, symptoms referable to these abnormalities may appear. Treatment is aimed toward alleviation of symptoms produced by the defects.

The inheritance of cleidocranial dysostosis has been carefully reviewed by Lasker.[332] Cleidocranial dysostosis is a rare developmental disease. The number of cases now known, 505 plus 30 doubtful cases, makes it advisable to reassess the dominant mendelian inheritance.

It primarily affects those bones which ossify from membrane, but all parts of the skeleton are sometimes involved. The head is typically large, low and branchycephalic, with persistence of the fontanelles and the metopic and other sutures. The most prominent clinical sign is the lack or the defect of the clavicles and the unusual motility of the shoulder girdle. Little if any disability is ordinarily apparent in affected persons. They usually live out a normal life span.

That cleidocranial dysostosis is a hereditary disease is strongly indicated by the frequency of the multiple familial occurrences and the distribution of cases. Seventy-three families have been reported in which the disease occurred in more than one person. In the seventy-three families, 369 persons are reported affected or probably affected.

Lasker concludes: "We may say with some assurance that the majority of cases of cleidocranial dysostosis are inherited as a Mendelian dominant with high penetrance. It is quite possible that all cases may be explained in this way if the responsible gene recurs frequently as a mutant."

Maddox [333] reports another case of cleidocranial dysostosis in a 21 year old man who had been in the British Navy two years. He says: "This dystrophy, no longer considered invariably as hereditary, is still sufficiently uncommon (it is doubtful whether 100 cases have yet been described) to warrant a record of fresh case reports."

[ED. NOTE (L.D. B.).—See preceding report for number of cases.]

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332. Lasker, G. W.: The Inheritance of Cleidocranial Dysostosis, Human Biol. **18**:103-126 (May) 1946.

333. Maddox, J. K.: Cleido-Cranial Dysostosis, J. Roy. Nav. M. Serv. **32**: 201-209 (July) 1946.

Its chief interest lies in its symptomless nature and in the adaptation to hard physical work exhibited by nearly all those affected. It is apparent that the clavicle, which appears as a strong link in the shoulder girdle of higher mammals who are intended to climb for their food, can be virtually dispensed with by civilized man. Its four components are aplasia of clavicles, exaggerated transverse diameter of cranium, delay of ossification of fontanelles and hereditary transmission. "A better tetralogy would be dysplasia of clavicles, delay in closure of skull sutures, defective development of the base of the skull and multiple vertebral anomalies."

Association with other congenital defects, including syringomyelia, places the deformity chronologically at an early fetal phase. The clavicle is the first bone in the skeleton to ossify (sixth week). In the argument on the significance of the remnants from the viewpoint of comparative anatomy, it is interesting to note that a consistent accompaniment is incomplete development of the pelvis and ischium, which correspond in the lower extremity of man to the coracoid and precoracoid of the upper extremity of lower animals.

It is important to reassure the affected person that, far from being physically inferior to his fellows, he possesses a unique faculty for escape from a strait jacket, through a ship's scuttle or down a drainpipe.

An unusual developmental abnormality of the arms is reported by the Shahs.[334] They report a case accidentally observed in the dispensary at Ahmedabad. A man of 20 had a bilateral deformity of the arms. The humerus had fused with the radius or the ulna, and there was a suppression of some of the carpal bones and of many of the metacarpals and phalanges, which gave him lobster claw hands.

From Oslo Støren[335] describes bilateral congenital ankylosis of the elbow in two sisters who were brought to him for examination. One of them was 1½ years and the other 6 months old. They were otherwise free from deformities, as were also their parents, whose only children they were. The mother's great-grandfather had three brothers who presented the same anomaly. In Norway there have now been described altogether 7 cases, including these 2. All the patients are from Sunmöore County, and they bear a remarkable resemblance to each other, but no relationship between the families can be found to exist.

The author operated on both elbows of the older child, on one of them when she was 1½ years old and on the other when she was 3.

334. Shah, K. A., and Shah, S. B.: An Unusual Developmental Abnormality of the Arms, Indian M. Gaz. **81**:10-11 (Jan.) 1946.

335. Støren, H.: Two Operated Cases of Ankylosis Cubiti Congenita, Acta chir. Scandinav. **94**:65-74, 1946.

The operation on the other child was performed when she was at the age of 6 months. The joint first treated showed good results for two and a half years, but the mobility has since decreased. The two joints last operated on have by degrees become stiff.

The author refers to Frostad's account of the development of the joint and of the manner in which this anomaly may be supposed to arise, and he regards it as probable that the muscular rudiments are to be found in the embryonic stage of life and that the muscles are still present at birth but comparatively soon become atrophied.

The operations also showed that the musculature of the elbows was present, although there was considerable atrophy (or absence of development?) both of the muscle and of the triceps tendon. It is worthy of note that the musculature was best developed in the arm earliest operated on. The operation must therefore be performed at the earliest possible age if a good result is to be expected. The author believes that the operation ought to be attempted, as improved technic and more careful after-treatment would probably yield better results than those reported.

The growth cannot be impaired by the operation, as epiphysial lines are not present. If stiffening of the joint should again take place, then care must be taken to secure the most convenient position possible. In most cases the power of rotation is probably preserved.

Patella cubiti, a rare anomaly in the elbow, has been described by Kjelland,[336] of Bergen, Norway. He reviews the literature and adds 2 cases of patella cubiti (os epiphyseos olecrani). The roentgenograms show a small bone embedded in the triceps ligament, with a probable cartilage-covered anterior surface and in form similar to the patella genus. Arthrography in 1 case revealed a recessus-superior-like extension of the joint cavity. An embryonic abnormality is assumed to be the cause.

Curr [337] reports two examples of fusion of the lunate and the triquetrum from the Royal Infirmary of Edinburgh. In both cases roentgenologic examination showed, on one side only, a complete fusion of the lunate and triquetrum, which was obviously a congenital abnormality and was not due to any acquired factor. At no time had there been any reason to suspect that the wrists were anything but normal, and the discovery of the abnormality was purely accidental.

Even though this condition is rare, it is of little importance since it does not interfere with appearance or function.

336. Kjelland, P. M.: A Rare Anomaly in the Elbow—Patella Cubiti, Acta radiol. **26**:491-496, 1945.

337. Curr, J. F.: Congenital Fusion of Lunate and Triquetrum, Brit. J. Surg **34**:99-100 (July) 1946.

Alexander and Stevenson [338] present the findings at necropsy in a case of spina bifida, with meningomyelocele.

In the literature, the term "anterior sacral meningocele" has been used to describe a meningocele found in the pelvis in front of the sacrum. In cases in which an adequate examination was possible, a bony defect in the body of the sacrum was usually found. Thus, in these cases there was an anterior sacral spina bifida with an associated meningocele. The case described appears to require a separate classification since the skeletal anomaly was a posterior spina bifida.

It is suggested by the authors that the term "anterior sacral meningocele" be reserved for cases in which the spina bifida is in the anterior portion or the body of the sacrum. "Intrapelvic meningocele" may be used to describe a meningocele lying within the pelvis, it being borne in mind that the meningocele may emerge from the sacral spinal canal either through an anterior sacral hiatus or through a posterior defect in the sacral laminas.

They reported a case of posterior sacral spina bifida associated with a meningocele that protruded into the pelvis through the left greater sciatic foramen and with a teratoma of the sacral region.

Treatment for congenital constriction bands of the extremities has been described by the late H. Eckstein, of Tel-Aviv, and P. M. F. Eckstein.[339] They describe what they think is a new operation for the "amniotic constrictions," or the annular scar-like depression of the skin. After excising the scar, they mobilize the proximal fat to fill in the defect:

> After excision of all fibrous scar tissue a tongue of fat was fashioned, superficially by undercutting the proximal skin edge and deeply by dissecting along the muscle plane for a corresponding distance. The resulting pad of fat was then drawn across the skin gap and beneath the distal skin edge, which had also been undercut for its reception. It was finally secured in its new site with a stitch passed through it and the overlying skin, where the thread was tied over a wad of gauze. Lastly, the original incision was sutured more proximally.

A case of hemihypertrophy is described by Rugel [340] which exhibited all the typical features of this condition, i. e., vascular cutaneous lesions, unilateral sweating, instability of temperature control, change in the hair and skin, cerebral abnormalities and the obvious inequality of the two sides. Postmortem study disclosed deviation from the accepted

338. Alexander, C. M., and Stevenson, L. D.: Sacral Spinal Bifida, Intrapelvic Meningocele and Sacrococcygeal Teratoma, Am. J. Clin. Path. **16**:466-471 (July) 1946.

339. Eckstein, H., and Eckstein, F. M. P.: Foetal Dysplasia of Leg, Lancet **1**:52-53 (Jan. 12) 1946.

340. Rugel, S. J.: Congenital Hemihypertrophy, Am. J. Dis. Child. **71**:530-536 (May) 1946.

picture of purely unilateral asymmetry. The brain showed tremendous hypertrophy and significant histologic changes.

As to etiology, they say that Gesell's twinning theory of "a union into one organism of two different halves" would fit their patient. They believe that hemihypertrophy is in some way tied up with an embryonic defect of the vegetative nervous system. This affects the trophic function of that system, and the result is a bizarre picture of hemihypertrophy.

Gram[341] describes 5 cases of hemihypertrophy. In 1 of the cases the malformation was combined with "av nevus flammeus" affecting the other half of the body with the exception of the head. As the vasal disturbance annoyed the patient, it was treated with Bucky rays, with good effect.

In the 4 other cases of pure hemihypertrophy the condition did not cause any harm. The defect is of general pathologic interest and should be known, as it gives rise to misinterpretations.

Scherb[342] discusses the causes of congenital deformities and gives the following summary:

> The work of W. Brandt on the larvae of amphibians in the caudal budding stage and the conclusions drawn by him as to the genesis of malformations of the limbs are discussed as well as his theories on induction and determination.
>
> The hypotheses of various authors as to the origin of congenital clubfoot are mentioned. In previous communications, the author attributed this deformation to the persistence of a phylogenic residue originating in the foetal shaping of the extensor brevis digitorum, interposed between the peroneus brevis and the tuberosity of the 5th metatarsal bone and which normally disappears during the third month of embryonic life. The origin of congenital clubfoot could then be rendered possible by the action of a gene inhabiting the general development and shaping of the entire foot and preventing the phenomena of induction from eliminating the phylogenic residue mentioned above before the critical or irreversible phase of determination. This residue thus persists and develops with the foot which, during the third month of embryonic life, is deformed and becomes a congenital clubfoot. The existence of a specific isolated clubfoot gene is therefore not likely.

Magnusson[343] reports another method of doing an osteotomy to correct inward torsion in cases of congenital clubfoot. He makes a transverse cut in the lower third of the tibia and an oblique cut in the upper third of the fibula. He says this operative procedure affords the following advantages:

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341. Gram, L.: Hemihypertrophy, Nord. med. **30**:1061-1063 (May 10) 1946.

342. Scherb, R.: Zur Frage der Entstehungsursache angeborener Gliedmassenmissbildungen mit besonderer Berücksichtigung des angeborenen Klumpfusses, Helvet. pædiat. acta **1**:99-109 (Nov.) 1945.

343. Magnusson, R.: Rotation Osteotomy, J. Bone & Joint Surg. **28**:262-264 (April) 1946.

1. The risk of faulty position in the tibial osteotomy is practically eliminated, as the fibula, untouched in its lower part, serves as a stabilizer.

2. A real derotation of the foot can be performed, with maintained congruence between the joint surfaces of the malleoli and the sides of the astragalus.

3. It is easier for the surgeon to control the derotation by this method than by other methods.

He reports seventeen operations on 13 patients.

[Ed. Note (J. H. K.).—Various methods of doing an osteotomy for the correction of inward torsion in cases of congenital clubfeet have been devised. Years ago I did a number of osteotomies for this purpose, but I have found little need for the operation during the last ten years. When the deformity of the foot has been well corrected, the osteotomy is seldom needed. When a clubfoot deformity recurs and the child toes in, the first impulse is to rotate the foot outward on the tibia. When the foot is examined more carefully, it is found in most cases that the adduction of the forefoot and the inversion of the foot have not been well corrected. I think the better procedure is to correct the deformities in the foot, and then it is found that the osteotomy is not necessary. Even if there still remains some inward torsion when the knee and foot are compared, the child with a well corrected clubfoot can still walk with the foot straight and can take care of considerable inward torsion without the need of an operation.]

Walter Mercer,[344] of Edinburgh, has reviewed most of the congenital deformities of the foot and mentioned the usual treatment. For clubfeet he recommends manipulation and the use of the Denis Browne splint for many months. In regard to arthrogryposis multiplex congenita, he says it is well to recognize this type of congenital clubfoot, since no treatment is likely to have any effect on the condition. The introductory paragraph is of interest:

> In a study of congenital disorders of the human foot it is natural to consider man's evolutionary history, since there is little doubt that ever since he evolved into that stage which made him pithecanthropus erectus he has been having trouble with his feet. Our ancestor of some twenty million years ago was a small tree-dwelling monkey which even then, by suspending himself by his arms, was being initiated into the vertical posture, although at that time taking no weight upon his feet. The foot was still prehensile and the innermost toe opposed the four outer to produce a grasp, and was therefore not unlike the average pronograde monkey of today. Because of an abundance of food the body increased greatly in bulk, so that the habit of progressing by his hands became a physical impossibility and he was forced to use his feet to help in the carriage of a proportion of

344. Mercer, W.: Congenital Abnormalities of the Foot, Practitioner **156**: 88-95 (Feb.) 1946.

his body weight. The continuing disproportion between body weight and strength of hand forced on him a permanent descent to the ground. For some time the early shuffling gait of pre-man was assisted by the hands, but as movements became more perfect the hand was liberated and the feet then bore the whole weight of the body.

[ED. NOTE (J. H. K.).—Arthrogryposis, while difficult to treat, can be corrected by a long series of casts and wedgings. A method which will correct this deformity is also good for the average congenital clubfoot.]

Gunn [345] reports 8 cases of clubfeet treated by the use of a rubber band held to the skin by adhesive plaster cuffs. He says that this treatment "results in no atrophy, no shortening, allows perfect form and perfect function and also that "all patients on whom the treatment was begun in the first week were cured with the exception of one infant whose mother failed to cooperate."

[ED. NOTE (J. H. K.).—There are many statements in the article which indicate an unfamiliarity with clubfeet. All extremities which are congenitally deformed show some atrophy and shortening, no matter how early the correction is obtained. The word "perfect" when applied to the form and function of a clubfoot after a short course of treatment sounds a little too good.]

Pierre Marique [346] has made a study of congenital clubfeet by the use of lateral bimalleolar roentgenograms, and he thinks that the anterior subluxation of a clubfoot on the leg is the crucial lesion. He expresses the opinion that it is this subluxation which makes it impossible to correct the equinus deformity, because the astragalus is blocked by the marginal border of the tibia.

He says that the treatment of choice for extremely young children consists in reductory manipulations. Since nothing is as frail as the ankle of a newborn infant, any manipulations must be avoided in the first days. The dogma of emergency, widespread by Sayre and by Bade, whose treatment must begin at birth, has led to too many accidents and must be rejected once and for all. One may wait until the end of the first month of life. Any brutality must be repudiated.

He makes the point that before the equinus deformity can be corrected the astragalus must be present exactly in front of the mortice; therefore, the posterior foot adduction has to be corrected. This is obtained much better by the grasp on the heel than by the medium of the forefoot. The reduction is gradually obtained. During the intervals

345. Gunn, R. E.: Foot Deformities Corrected by Rubber Band Traction, J. Iowa M. Soc. **36**:48-50 (Feb.) 1946.

346. Marique, P.: La subluxation du pied bot, Presse méd. **54**:411 (June 22) 1946.

of ten to fifteen days between the sittings, a plaster cast is applied to the foot in the position obtained with effort.

He recommends the use of an anesthetic because the child's movements of defense block the manipulations. Section of the achilles tendon is unnecessary. The flexion of the knee relaxes it enough. When the foot has taken up its normal place under the tibial arch and the osseous contact does not play a part any more, the dorsiflexion becomes possible and the triceps lets itself be stretched.

[Ed. Note (J. H. K.).—The astragalus is a little farther forward in relation to the tibia in a clubfoot than in a normal foot, but the posterior end of the astragalus is always under the tibia. From a study of roentgenograms, I do not see how there could be any bony block which would keep the astragalus from being pushed back under the tibia into the mortice between the malleoli. Some have thought that the head of the astragalus was larger than normal and that this prevented it from being pushed back under the tibia. Malformations in the ankle joint may play a part in resisting correction, but in the cases in which I have operated there has always been a much enlarged achilles tendon, and I feel that this has more to do with blocking dorsiflexion than any disturbance of the alinement of the astragalus. All the ligaments about the posterior foot and the tibia offer resistance to correction. When a series of lateral roentgenograms are studied from the beginning of treatment until the foot has been well corrected, it is found that the os calcis has drawn forward under the astragalus. Before treatment, the head of the astragalus overlaps the anterior end of the os calcis, but by the time the foot comes well up in dorsiflexion the anterior ends of the two bones are on the same level. It is also noticed that the astragalus has been pushed back under the tibia about the normal amount when the ankle comes up in full dorsiflexion.]

Blumenfeld, Kaplan and Hicks [347] have given a fair appraisal of the treatment of congenital clubfeet, with a review of the literature, and have reported the results obtained by three methods from the State University of Iowa. After a careful analysis of their cases, they give the following conclusions:

> Treatment of clubfoot should be instituted as early as possible. The Denis Browne splint, alone or complemented in some cases by another form of conservative therapy, gives the best results, especially in patients under one year of age. In cases in which the Denis Browne splint failed to obtain complete correction, or in those patients who are between one and four years of age at the beginning of treatment, wedged casts should be used. In some cases of metatarsus varus, correction can be accomplished with wedged casts. Under certain conditions in private practice, manipulative methods may not be the method of

347. Blumenfeld, I.; Kaplan, N., and Hicks, E. O.: Talipes Equinovarus, J. Bone & Joint Surg. **28**:765-777 (Oct.) 1946.

choice, but rather of necessity. In expert hands, good results can be obtained by the manipulative method. The manipulative method can be used in patients in the older age groups. Metatarsus varus can either be completely corrected or markedly improved by manipulative methods. Correction must be maintained for a considerable period of time, preferably as described.

This article describes a special cassette holder fashioned out of wood which is used to help in holding the child's feet still and in correct position when roentgenograms are made. This should be useful in getting a true anterior-posterior view.

They mentioned another finding which is interesting: "Most of the well corrected congenital clubfeet treated by wrenchings are pliable. Incompletely corrected feet are usually rigid."

[ED. NOTE (J. H. K.).—They explained that the word "wrenching" is used to denote forceful manipulation under anesthesia, without the use of the Thomas wrench and the wedged bar. It has been my opinion that the rigid feet resulted from the use of too much force. I am sure that if only a little more force is used than could be used with the patient awake, more improvement can be obtained. It is the "gentle manipulation" which is permissible and needed in treatment of the older and more resistant feet. At the close of their article the authors make a significant statement, i. e., "The personal equation of the doctor treating the patient is of the utmost concern, because of the necessity for meticulous care in the taking of the wedges and the application of casts."]

Dr. Stuart A. Thomson,[348] of Toronto, who introduced the Denis Browne splint into this country, has designed a spring splint to be used for the older and more difficult clubfeet. "The design of the splint is simply a lateral single bar below the knee brace, with a stop joint. It is fitted on our standard club-foot boot, which is a good boot with a low heel and a thick sole and an outside wedge of three sixteenths of an inch on heel and sole. The two segments of the splint are then united by an adjustable hinge-like apparatus with an intervening spring." He says that with "the advent of the spring splint, the results in recurrent club-foot have improved tremendously."

[ED. NOTE (J. H. K.).—It may be that I have been neglecting the after-care of clubfeet. I never have the children wear a special shoe, or a lift under the lateral border or a night splint. I do have some recurrences, but I think of these as being due to inadequate correction. I believe that if the foot is well corrected the child can wear a normal shoe and lead a normal life, without the parents doing more than stretching the foot in dorsiflexion for a while after the casts are removed.]

348. Thomson, S. A.: A Splint for Treatment of Recurrent Clubfoot, J. Bone & Joint Surg. **28**:778-779 (Oct.) 1946.

A method for treating an uncorrected clubfoot in childhood has been described by Batchelor.[349] The procedure is for a child between 5 and 10 who has an imperfectly corrected foot. "Manipulative trauma tends to produce a vicious circle of false corrections, increasing fibrosis and stiffness, followed by inevitable relapse of deformity, and yet more manipulations and wrenchings." He says that the deformity occurs essentially at the astragalocalcaneoscaphoid joint. The os calcis moves with the forefoot, and if the deformity at the astragaloscaphoid joint can be corrected by drawing the scaphoid around the head of the astragalus, the inversion of the heel will disappear. He states that the astragalus is too long and that it is impossible to draw the scaphoid around it. He shortens the neck of the astragalus by removing a section approximately one third of an inch wide. This allows the scaphoid to be drawn up and out around the head of the astragalus. The gap in the neck is closed. "Immobilization is maintained for four to five months, and the child is then provided with an outside iron, outside T-strap and quarter-inch outside wedge on the sole of the boot." It is claimed that this treatment gives the patient not a perfect foot but a foot on which he can get about until he is old enough for a formal arthrodesis, if this should be necessary.

The medical profession has been criticized for lack of recognition and adequate correction of many disabilities which showed up in army inductees, says Thomson.[350] Among the common disabilities of the foot was symptomatic flatfoot. The pediatrician must look for and recognize physical anomalies and evidences of weakness in the baby's foot and must realize that a child does not necessarily have normal feet because he does not have clubfeet.

Some infants have abnormal mobility of the foot in all directions and a particular fondness for an everted calcaneovalgus position. These babies have the tendency to throw their feet, while kicking, from a varus to an extreme calcaneovalgus position. Usually the dorsum of the foot can be brought manually and without force against the anterolateral part of the leg. The babies often sleep on their bellies, and in this position they habitually evert their feet. When they learn to sit, they assume a position of abduction, with the knees flexed and the feet everted. The eversion of the feet is exaggerated during crawling. When the infant begins to walk, the legs rotate outward, and pronation and eversion of the feet are thereby exaggerated.

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349. Batchelor, J. S.: The Treatment of the Uncorrected Clubfoot in Childhood, Proc. Roy. Soc. Med. **39**:713-715 (Sept.) 1946.

350. Thomson, J. E. M.: Treatment of Congenital Flat-Foot, J. Bone & Joint Surg. **28**:787-790 (Oct.) 1946.

Thomson treats these feet with a "reverse" Denis Browne splint. The feet are strapped to the splint as in the correction of clubfoot except that the bar is bent toward the crotch. When the feet are large enough for shoes, the shoes are attached to the bar to be worn at night.

Dr. J. Warren White, in the discussion of this paper, agrees that the method is excellent and says that in mild cases he has been sticking together the soles of the infants' hypermobile flaccid feet with a commercial adherent or a compound tincture of benzoin and holding them with a 2 inch (5.08 cm.) elastic bandage.

[ED. NOTE (J. H. K.).—In many of these cases of calcaneovalgus feet the outward rotation of the entire leg seems to be a more serious abnormality than the flatfeet. I am observing many more cases of outward rotation of the legs than formerly. In addition to having the mother hold the legs in an inwardly rotated position and the feet in a position which will restore an arch in them, I have been using the reverse Denis Browne splint, and I find it exceedingly useful. I have the shoes attached to the bar so that the rotation can be adjusted and the amount of inward rotation increased as needed.]

A case of congenital talonavicular synostosis associated with hereditary multiple ankylosing arthropathies in a soldier is described by Weitzner.[351] This was a case of bilateral deformity, with multiple fusions of bones in hands, wrists and feet. A short embryologic aspect of joint development is outlined.

A calcaneoscaphoid bar is reported in 2 soldiers by Magee and Benson.[352] One noticed pain after marching 29 miles. The other had stiffness in the ankle. The diagnosis was made only by roentgenologic study. The condition is a congenital ossification in mesenchyme which would ordinarily form the lateral part of the short plantar ligament. The roentgenogram showed a solid bar of bone uniting the anterointernal angle of the calcaneus with the navicular. Abduction and adduction were limited to about half their normal range, and eversion and inversion were absent, but there was no pain on forced movements.

A case of anomalous skeletal development in the foot is described by Sloane.[353] A reduction in the usual number of bones may be effected by fusion or by imperfect definition of those normally present. The feet described were those of a cadaver. The right foot had only four

351. Weitzner, I.: Congenital Talonavicular Synostosis Associated with Hereditary Multiple Ankylosing Arthropathies, Am. J. Roentgenol. **56**:185-188 (Aug.) 1946.

352. Magee, R. K., and Benson, R. A.: Calcaneo-Scaphoid Bar, Canad. M. A. J. **55**:287 (Sept.) 1946.

353. Sloane, M. W. M.: A Case of Anomalous Skeletal Development in the Foot, Anat. Rec. **96**:23-26 (Sept.) 1946.

toes. The head of the talus was fused with the navicular in each foot, and the calcaneum was fused anteriorly with a small, narrow cuboid. The talus was also fused with the calcaneum below. Other minor variations were noted.

Mooney [354] described an 8 year old girl with a fracture of the fibula. There was an absence of the tibia and of some of the bones of the foot. He was able to trace syndactylism, cleft hands and cleft feet and intrauterine amputations back in the family for four generations and had the photographs to prove it.

Claussen [355] reports a hereditary syndrome consisting of malformation of the tongue and polydactyly. Two children suffering from polydactyly and malformation of the tongue are reported. The first child had two normal sisters and one normal brother; three brothers had congenital deformities and died during their first year. The second child had one normal brother. Consanguinity existed between the two families, and in the second case consanguinity between the parents was proved. Genealogic investigations showed that the malformations were caused by a recessive gene.

O'Rahilly [356] describes the roentgenograms made of a girl's foot when she was 3 and again when she was 7. He says that the fate of a supernumerary phalangeal epiphysis was followed roentgenologically; the foot also showed hypophalangism and then hyperphalangism with subsequent symphalangism. Relevant cases from the literature are cited.

Stiles and Hawkins [357] discuss webbed toes under the title of zygodactyly. The term zygodactyly was coined by Weidenreich to designate simple webbing between the toes, in contrast with syndactyly, wherein fusion or abnormality of the bony structure of hands or feet is involved.

The webbing characteristic of zygodactyly usually involves the skin and superficial fusion between the second and third toes. Cases have been reported in which other toes have been affected, and Whitney even states that complete webbing of all toes has been reported. The extent of the webbing varies considerably; in some feet it extends to the first joint and in still others to the tip of the toes. Schurmeier, in a study

354. Mooney, V.: Orthopaedic Interest in a Fracture, Pennsylvania M. J. **49**:736-738 (April) 1946.

355. Claussen, O.: Hereditary Syndrome Comprising Malformation of Tongue and Polydactylia, Nord. med. **30**:1147-1151 (May 24) 1946.

356. O'Rahilly, R.: Radiological Investigation of a Case of Pedal Hyperphalangism and Supernumerary Phalangeal Epiphysis, Brit. J. Radiol. **19**:432-434 (Oct.) 1946.

357. Stiles, K. A., and Hawkins, D. A.: The Inheritance of Zygodactyly, J. Hered. **37**:16-18 (Jan.) 1946.

of 20,000 drafted men, found only 8 who possessed this trait, the webbing always being between the second and third toes.

It is normal for the toes to be webbed when the fetus is from 5 to 6 weeks old. The web appears to be slightly more extensive between the second and third toes. As the digits develop and elongate, the webbing becomes less noticeable, and the toes by the end of the eighth week become separated, that is, the webbing is reduced to mere remnants at the base of the digits. In the case of zygodactyly, the webbing grows outward with the toes instead of becoming reduced. It can be seen from the embryogeny of webbed toes that zygodactyly appears at birth, but it does not increase as the person grows older.

They publish a pedigree which reveals that 5 persons possess this trait. In every case the webbing extends only to the first joint and in no way impairs the function of the toes. The pedigree reveals that this trait is conditioned by a dominant gene with reduced penetrance. Persons presumably heterozygous for the trait sometimes have normal toes.

Webbing, or zygodactyly, of the second and third toes is not an uncommon human anomaly. Webbing of the third and fourth fingers is rarer, but the occurrence of an interdigital triradius, which marks the site of the webbing, can be present even though the webbing is barely noticeable. In zygodactyly there is no osseous malformation like that found in syndactyly or polydactyly. Penrose [358] found that it is more than twice as frequent in males as in females. He has analyzed the material from a number of published pedigrees and has shown that paternal hereditary influence predominates over maternal influence. The phenomenon is interpreted as evidence that the trait is primarily due to incompatibility of the mother to some unknown fetal antigen inherited from the father.

Pipkin and Pipkin [359] present a paper to describe polydactyly of the feet only, in which expression both of the abnormality and of its hereditary transmission are highly irregular. They say that in many pedigrees polydactyly is dependent on an irregular dominant gene; that is, the defect is occasionally transmitted by a normal-appearing carrier. In most polydactylous families there is a wide variability in the expression of the abnormal condition. Either or both hands together with either or both feet may be affected. The extra finger or toe may vary from a well formed digit with phalanges and even its own metacarpal or metatarsal bone to a mere fleshy protuberance. Variation in the structure and position of the extra digit often occurs among different affected members of the same pedigree.

358. Penrose, L. S.: Inheritance of Zygodactyly, J. Hered. **37**:285-287 (Sept.) 1946.

359. Pipkin, S. B., and Pipkin, A. C.: Variation of Expression of Polydactyly, J. Hered. **37**:93-96 (March) 1946.

Spear [360] has made a study of flexed fingers in his own family, where the condition has involved 8 persons, including members of both sexes and in five different generations. The terms "camptodactyly" and "minor streblomicrodactyly" may be considered as synonomous. He prefers the term camptodactyly in reference to flexed fingers. Hefner has reported the condition to be a result of a shortening of the tendon of the flexor digitorum sublimis muscle, which controls the movement of the finger. The finger affected is the little finger, though others may occasionally show the defect too. The condition being one of permanent flexion to varying degrees, the person affected cannot straighten the finger, and it remains in a state resembling an inverted V. Camptodactyly seems to be due to a single dominant, with the phenotypic expression influenced by genetic and environmental modifiers. There is evidence that the character is linked with hair color, but the data are not extensive enough to prove the point.

360. Spear, G. S.: The Inheritance of Flexed Fingers, J. Hered. **37**:189-192 (June) 1946.

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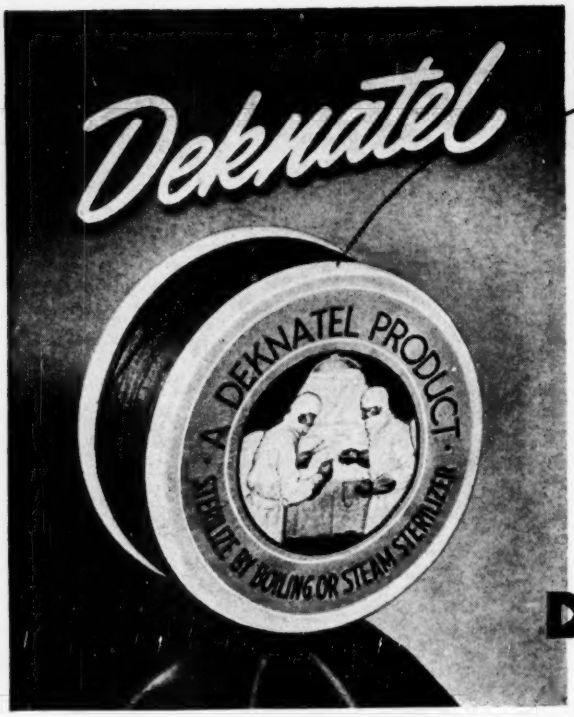

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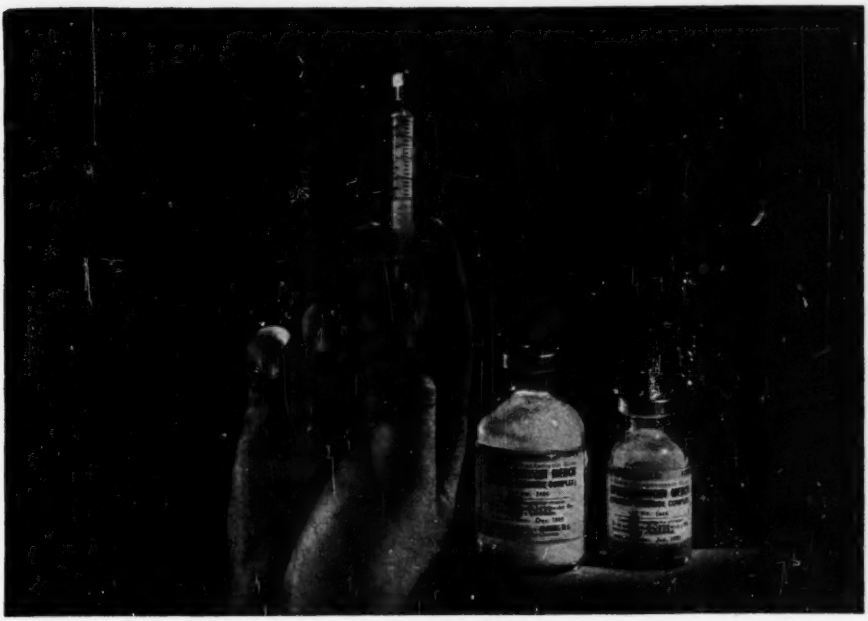

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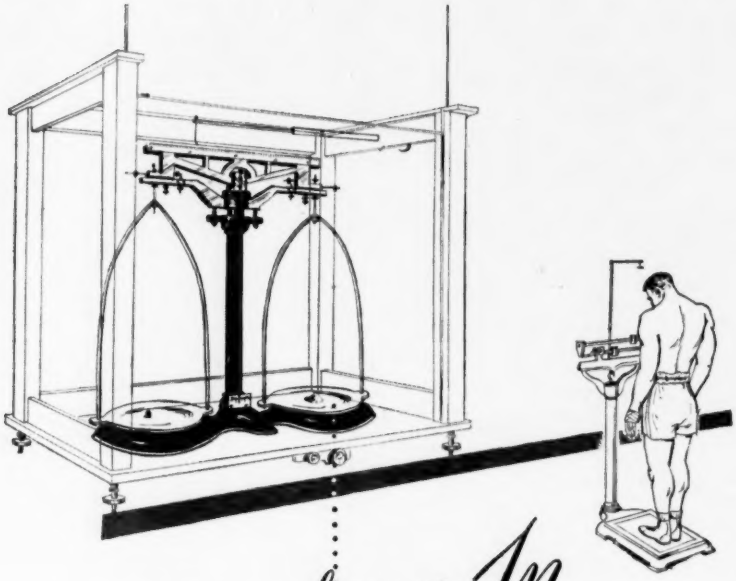

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